DECEMBER 26, 1960
Published every-other-Monday
Seventy-five cents

Chemical Engineering

A McGRAW-HILL PUBLICATION

New Process Kinetics
Page 83

Information Retrieval
Page 88

H_2SO_4: New Tricks
Page 99

Annual Editorial Index
Page 131

Photomicrograph of an air bubble entrapped in a lacquer film on mahogany panel.

Portrait of a problem . . .

Problems abound at every step in surface coating formulation and application. This portrait of a tiny blister represents only one of many challenges Shell Chemical technicians encounter in their continuing program of practical and theoretical research.

Shell's high quality ketones, alcohols, and intermediates, coupled with technical assistance to surface-coating formulators, lead to products of superior performance and greater economy. Use of the chemicals listed at the right can help you improve your line of products.

* * *

Why not become better acquainted with the many chemicals and services that are available to you through Shell Chemical? Write or phone your nearest district office for information concerning your special field of interest.

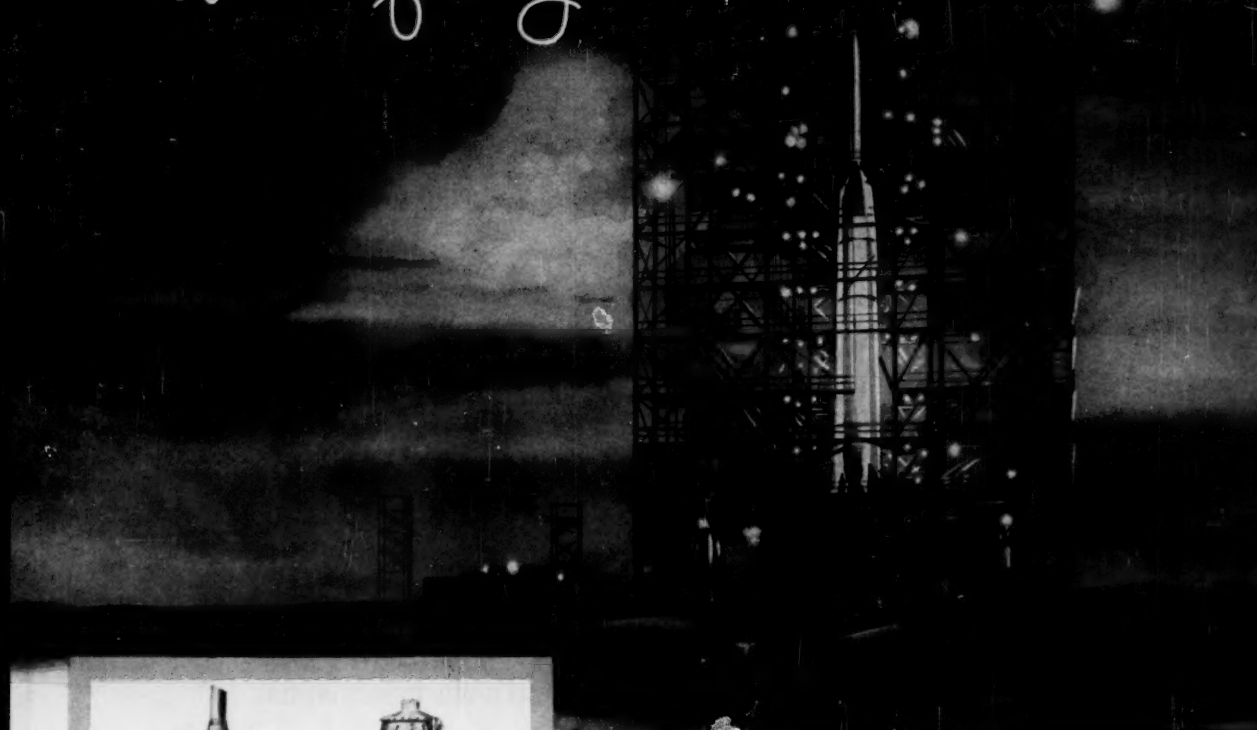
Acetone
Diacetone Alcohol
Di-Tertiary Butyl Peroxide
Ethyl Alcohol
Ethyl Amyl Ketone
Glycerine
Hexylene Glycol
Isopropyl Alcohol
Mesityl Oxide
Methyl Ethyl Ketone
Methyl Isobutyl Carbinol
Methyl Isobutyl Ketone
Neosol® Proprietary Solvent
p-Tertiary Butyl Benzoic Acid
Secondary Butyl Alcohol

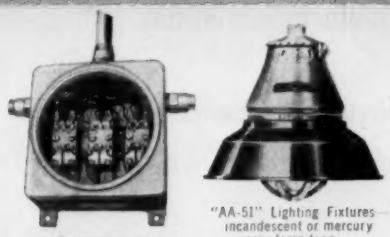
SHELL

SHELL CHEMICAL COMPANY
INDUSTRIAL CHEMICALS DIVISION

Atlanta • Chicago • Cleveland • Detroit • Houston • Los Angeles • Newark • New York • San Francisco
IN CANADA: Chemical Division, Shell Oil Company of Canada, Limited, Montreal • Toronto • Vancouver

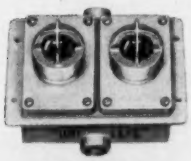
Where quality construction counts . . .





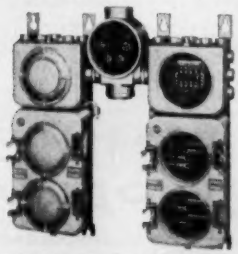
Type "GUB" Unilets—where junctions are required

"AA-51" Lighting Fixtures—incandescent or mercury vapor lamp type . . . more light, at less cost



"EFD" Series—dust-tight pilot light and switch Unilets

"SFN" Sealing Unilets—for sealing off conduit systems at required points



Type "ELP" Dust-Tight Panel Boards—With Covers Removed. Has a range from 2 to 16 circuits . . . 15 to 30 ampere ratings

depend on

APPLETON®

Explosion Proof
Electrical Equipment

Wherever up to date protection is needed in "hazardous" areas, you can count on APPLETON to safeguard any installation from a rocket launching pad to a grain elevator. APPLETON engineering, manufacturing skills and quality controls assure you the very finest in electrical fittings . . . all supplied from one source. Whether it's a coal mine or hospital, oil refinery or dairy, depend on APPLETON for the best in electrical fittings, lighting, panelboard or other equipment.

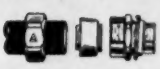
Sold Through Franchised Distributors Only

APPLETON ELECTRIC - PRODUCTS®

APPLETON ELECTRIC COMPANY
1701 Wellington Avenue Chicago 13, Illinois

Also Manufacturers of:

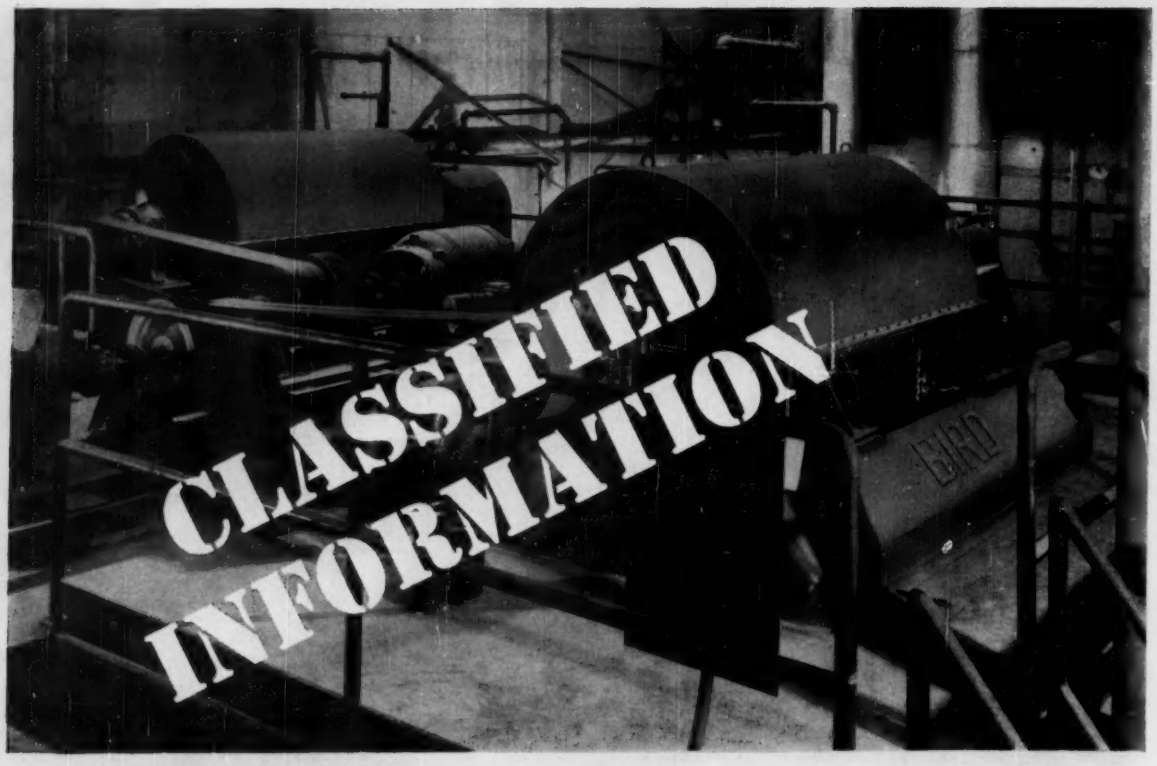
Industrial Lighting Equipment



"ST" Series Connectors

Explosion-Proof Junction Unilets

Explosion-Proof Reelites



It's no secret that this BIRD CONTINUOUS SOLID BOWL CENTRIFUGAL is widely and successfully used as a *CLASSIFIER*

for effective sharp cuts of solids in liquid suspension with the solids as coarse as 325 mesh and as fine as one micron

Advantages of Bird Centrifugal classification in addition to super-precise size separation are:

small volume in process — no storage problem

automatic solids dispersion — effected mechanically

handles heavy feeds — no pre-dilution or post-thickening problems

low cost operation in small space — 100 t.p.h. capacity requires only 150 sq. ft.; savings in power and maintenance often make it highly profitable to replace big, cumbersome classification equipment

The Bird Research and Development Center is equipped to furnish accurate data on performance, results and savings as they apply to your specific classification problem.

BIRD MACHINE COMPANY
SOUTH WALPOLE, MASSACHUSETTS

BUILDERS OF THE COMPLETE LINE OF SOLID-LIQUID SEPARATING EQUIPMENT

Operators of the **Bird Research and Development Center** for pilot-scale testing to determine the correct equipment for the job. Yours to use.

Application Engineering Offices:
EVANSTON, ILL. • ATLANTA, GA. • HUNTINGTON, W. VA. • LAPORTE, TEXAS • WALNUT CREEK, CALIF.

Chemical Engineering

December 26, 1960

CHEMICAL TECHNOLOGY FOR PROFIT-MINDED ENGINEERS

PRINT ORDER FOR THIS ISSUE 52,852

WHAT'S HAPPENING

31 CHEMENTATOR *R. A. Labine*

40 INDUSTRY NEWS *A. V. Gemmill*

Calciner Streamlines Gypsum Process *41*

Jet Engine Is Grounded to Drive Compressor *42*

New Absorbents Cut H_2S Removal Cost *44*

CPI News Briefs *48*

50 CHEMICAL ECONOMICS *Frances Arne*

Oil-Based Aromatics Gain First Place *R. F. Messing, J. W. Bradley*

62 NEW CHEMICALS *E. Guccione*

What's New in Refractories

68 NEW EQUIPMENT *F. C. Price*

Equipment Cost Index *128*

71 PROCESS FLOWSHEET *N. P. Chopey*

Hardboard Plant Boasts Modern Look

ENGINEERING PRACTICE

83 FEATURE ARTICLES

Process Kinetics Can Predict Reaction Mechanism *H. Eyring* ***83***

Information Retrieval: What Will It Do? *J. W. Perry* ***88***

H_2SO_4: Old Dog, New Tricks *D. B. Burkhardt* ***99***

FREE—For your files, an extra copy of this article. Check Reader Service Postcard, p. 152.

Systems Engineering Literature *T. J. Williams* ***101***

107 PLANT NOTEBOOK *T. R. Olive*

Constant Rate Lab Feeder Can Be Adapted to Plant *C. F. Roberts* ***107***

Process Variables by Chart *G. Marino* ***108***

110 CE COST FILE *W. C. Schall*

Ductwork *R. T. Witherspoon*

112 CORROSION FORUM *R. B. Norden*

Fabrication: Key to Mixer Corrosion *N. H. Parker*

135 ANNUAL EDITORIAL INDEX

OTHER REGULAR FEATURES

122 CONVENTION CALENDAR

129 TECHNICAL BOOKSHELF

131 LETTERS: PRO & CON

151 READER SERVICE POSTCARD

153 REPRINTS NOW AVAILABLE

154 MANUFACTURERS' LITERATURE

161 CLASSIFIED ADVERTISERS

168 INDEX OF ADVERTISERS

168 ADVERTISING REPRESENTATIVES

VOLUME 67, NUMBER 26

Chemical Engineering (with Chemical & Metallurgical Engineering) is published biweekly by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder.

Publication Office: 99-129 North Broadway, Albany 1, N. Y.

Executive, Editorial, Circulation and Advertising Offices, 330 West 42nd St., New York 36, N. Y. **Officers of the Publications Division:** Nelson L. Bond, President; Shelton Fisher, Wallace F. Traendly, Senior Vice Presidents; John R. Callaham, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venezian, Vice President and Circulation Coordinator. **Officers of the Corporation:** Donald C. McGraw, President; Joseph A. Gerardi, Hugh J. Kelly, Harry L. Waddell, Executive Vice Presidents; L. Keith Goodrich, Vice President and Treasurer; John J. Cooke, Secretary.

Subscriptions are solicited from engineers and other technical men in the Chemical Process Industries. **Position, company connection, and nature of company's business, products, and approximate number of employees, must be indicated on subscription application.** Subscription rates per year for individuals in the field of the publication: U. S. and Possessions $7 (single copies 75¢). **Canada $4, other Western Hemisphere $15, all others $25. The publisher,** upon written request from any subscriber, agrees to refund the part of the subscription price applying to copies not yet mailed.

Second class postage paid at Albany, N. Y. Printed in U.S.A.

Title registered in U.S. Patent Office. ©Copyrighted 1960 by McGraw-Hill Publishing Co., Inc. All rights reserved. Member A.B.P., A.B.C.

Subscriptions: Send correspondence and change of address to Fulfillment Manager, Chemical Engineering, 330 West 42nd Street, New York 36, N. Y. Send notice promptly for change of address, giving old as well as new address. Enclose an address label from a recent issue of the magazine if possible. Allow one month for change to become effective.

Postmaster: Please send form 3579 to Chemical Engineering, 330 W. 42nd St., New York 36, N. Y.

Audit Bureau of Circulations

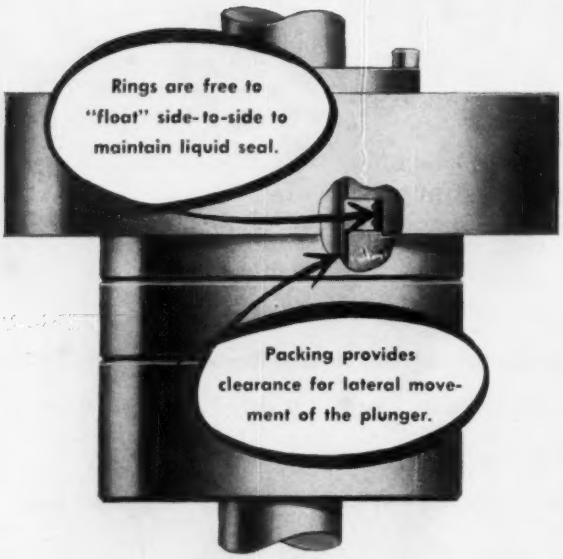
Associated Business Publications

ENGINEERING

NEWS YOU CAN USE ABOUT ENGINE AND COMPRESSOR PERFORMANCE

THIS LIQUID-PUMP PACKING ACTUALLY FLOATS TO ELIMINATE COSTLY LEAKAGE PROBLEMS

Cook's special full-floating, self-adjusting packing boosts performance, reduces downtime of high-pressure plunger pumps


Rings are free to "float" side-to-side to maintain liquid seal.
Packing provides clearance for lateral movement of the plunger.

Plungers of all liquid pumps tend to "run out of true." As a result, conventional packings must make room for this lateral movement with a clearance around the plunger. Thus, a path is soon formed and excessive leakage occurs. This leakage can be reduced by adjustment but soon starts again.

To eliminate this annoying and expensive packing problem, Cook has designed a special liquid-pump packing which has proved itself in a number of varied field applications. This Cook packing actually *floats with the movement of the plunger*. It doesn't have to make room for the "run-out" of the plunger—it simply moves with it!

Cook packings are now successfully handling all types of liquids—oil, water, chemicals, brine, etc.—under many special operating conditions. These self-adjusting packings now make possible trouble-free performance without frequent adjustments. They are adaptable to all new or existing pump designs and become part of the permanent pump assembly. Ask a C. Lee Cook representative to give you the details about this special liquid-pump packing.

WRITE FOR MORE INFORMATION

If you want Cook engineers to review the special requirements of your specific liquid-pump packing application, just send the necessary details to C. Lee Cook Company, 958 South Eighth St., Louisville 3, Ky. Or send for complete information about any of Cook's complete line of rings and packings.

COOK SEALS LIQUIDS AT EXTREME PRESSURES AND TEMPERATURES

C. Lee Cook has unique experience in the advancement of liquid-seal technology. Recently completed research and development contracts (one with a major airframe and missile manufacturer) have resulted in new concepts of seal design, materials compatibility, friction limitations and sealing efficiency. If yours is a special packing application, call in a Cook representative.

C. LEE COOK COMPANY
Division of Dover Corporation
Rings and Packings Since 1922

Chemical Engineering
DECEMBER 26, 1960

PUBLISHER
J. Elton Tuohig

EDITOR-IN-CHIEF
Cecil H. Chilton

WHAT'S HAPPENING
EDITOR: Calvin S. Cronan
ASSOCIATE EDITORS: Frances Arne, A. V. Gemmill
ASSISTANT EDITORS: Nicholas P. Chopey, Eugene Guccione, Roland A. Labine, Frederick C. Price

ENGINEERING PRACTICE
EDITOR: Theodore R. Olive
ASSOCIATE EDITORS: Steven Danatos, Robert B. Norden, William C. Schall
ASSISTANT EDITORS: Peter J. Brennan, James R. Marshall

PRESENTATION & PRODUCTION
EDITOR: Lester B. Pope
SENIOR ART EDITOR: Frank F. Koselek, Jr.
ASSOCIATE ART EDITOR: Louis H. Dufault
ASSISTANT ART EDITOR: D. Caratzas
COPY EDITOR: Henry S. Gordon
EDITORIAL ASSISTANTS: Joan Nilsen, Nancy Pepicello

REGIONAL EDITORS & BUREAUS
HOUSTON: Thomas H. Arnold, Wilma Cortines
SAN FRANCISCO: Martin D. Robbins, Terry Shaw
DOMESTIC NEWS BUREAUS: Atlanta, Chicago, Cleveland, Dallas, Detroit, Los Angeles, San Francisco, Seattle, Washington
WORLD NEWS BUREAUS: Beirut, Bonn, Caracas London, Mexico City, Moscow, Paris, Rio de Janeiro, Tokyo. Correspondents in 153 cities in 61 countries.

CIRCULATION
MANAGER: Paul W. Erb

ADVERTISING & BUSINESS
ADVERTISING SALES MANAGER: D. B. Gridley
BUSINESS MANAGER: Anton J. Mangold
PROMOTION MANAGER: Hugh T. Sharp
MARKET RESEARCH MANAGER: Jeanette Paschall
ADVERTISING MAKEUP: Grace Barrie

highlights of this issue

OIL-BASED AROMATICS GAIN FIRST PLACE

New petrochemical technology is moving in fast to fill the vacuum in the supply of basic aromatic chemicals. With coke-oven sources unable to meet growing demands, petroleum refiners are embracing new dealkylation processes to boost their production of benzene and naphthalene. Arthur D. Little's Messing-Bradley team covers the field of aromatic sources and markets in this fifth and final installment of its 1960 petrochemical reviews (p. 50).

INFORMATION RETRIEVAL: WHAT'S IN IT FOR YOU?

Wiser decisions in all areas of business and technology will grow out of improved methods of information retrieval, according to J. W. Perry in this paper from our recent Conference on the New Chemical Engineering (p. 88). "It seems certain that information retrieval and related methods will contribute as importantly to decision making as electronic computation has to accounting and to solving complex problems in engineering design," says Perry. Traditional library methods for classifying information must eventually be supplanted by mathematical systems to realize maximum benefits.

POTPOURRI OF INDUSTRY NEWS

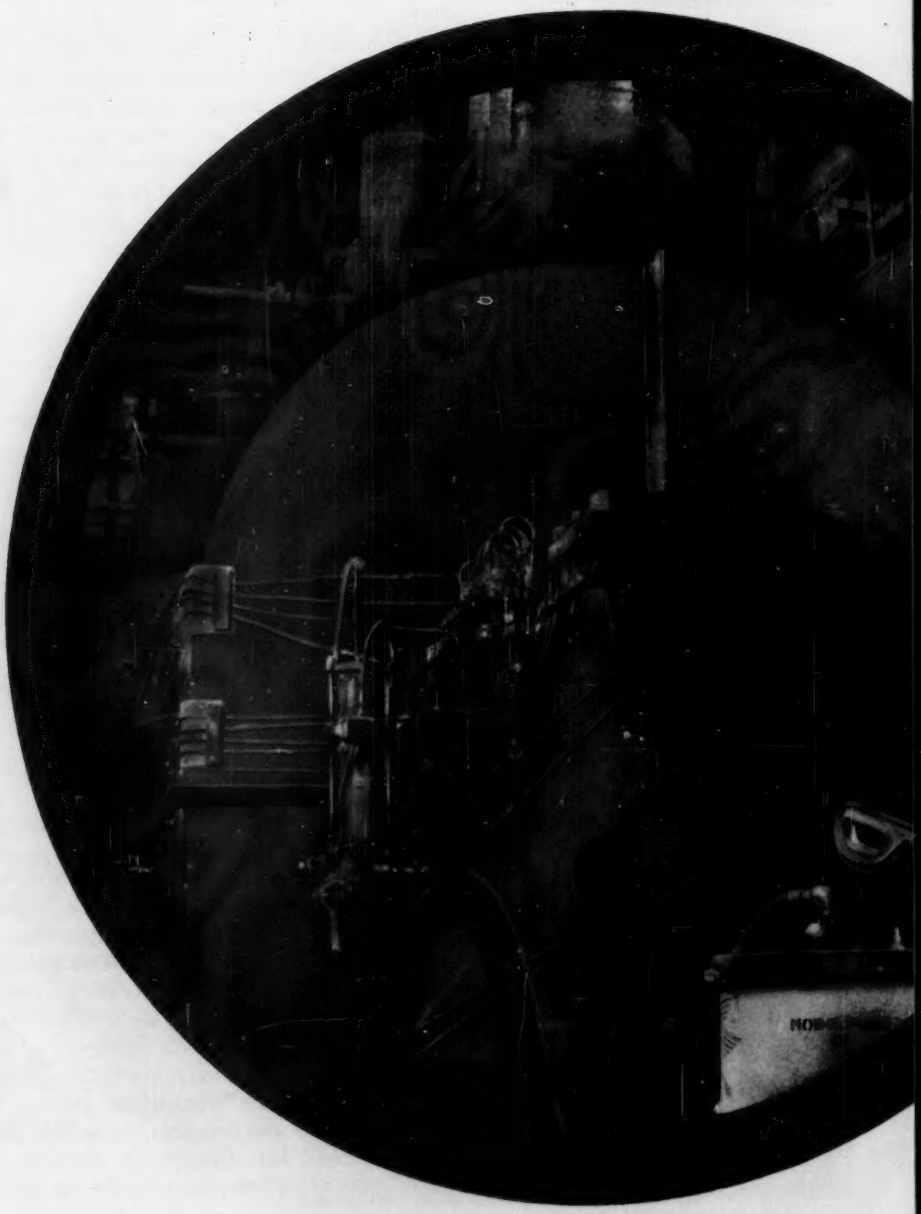
Here's a trio of noteworthy technical developments reported for your year-end reading:

• Gypsum calcining has now gone continuous (p. 41). Batch calcining kettles can be supplanted by a continuous, indirectly heated kiln to dehydrate gypsum rock more efficiently and turn out a better-quality product.

• A 10,500-hp. aircraft jet engine is now driving a centrifugal compressor on a natural gas pipeline in Kentucky (p. 42). Despite low efficiency of the jet-engine driver, offsetting advantages are outstanding.

• A new absorption process removes H_2S from gas streams and converts the sulfide directly into elemental sulfur (p. 44). Chemically reactive absorbent—a water solution of anthraquinone salts—is key to the process.

Mobilplex ep



The Multi-Service Grease with unique Calcium EP Complex. Never before in a single lubricant such a wide range of use . . . such a margin of superiority . . . such a potential for maintenance savings.

Above: Mobilplex EP produces excellent results in Timken OK-Load tests, provides outstanding performance in heavy-duty equipment.

Heavily loaded bearings like this grease-lubricated bearing of a Farrel-Birmingham Banbury mixer last longer, require less maintenance with Mobilplex EP.

Outstanding load-carrying ability is one of the many important properties of Mobil's new Multi-Service Grease —*Mobilplex EP*. In your washing, breakdown, mixing and calendering operations, you'll find Mobilplex EP offers maximum protection against heavy and shock loads. It also offers excellent resistance to heat and extra protection against water and rust.

This Multi-Service grease has outstanding oxidation resistance as well as excellent structural and storage stability. These qualities—plus the great versatility of Mobilplex EP—make it useful throughout the plant.

Plant operators throughout the country are finding Mobilplex EP extremely effective in extending bearing life and protecting production schedules. In addition, they're saving more than with ordinary multi-purpose greases because Mobilplex EP makes it possible to reduce application frequency, simplify storage and handling procedures.

Contact your Mobil representative for full details. He can show you results of laboratory performance tests of Mobilplex EP and five leading competitive extreme-pressure greases. You'll see why Mobilplex EP is rated tops!

MOBIL OIL COMPANY, INC. 150 East 42nd St., N. Y. 17, N. Y.

MULTI-SERVICE ABILITY OF MOBILPLEX EP

ANTI-FRICTION BEARINGS (*horizontal and vertical*). Temperatures in the range of 300 F. Heavy or shock loads. Water contamination. Speeds—low, normal, high.

PLAIN BEARINGS All normal mechanical and operating conditions. Temperatures in the range of 300 F. Waterwash. Heavy or shock loads.

DISPENSING AND APPLICATION DEVICES Transfer pumps. Hand and power guns (*long lines*). Central greasing systems.

Mobil

Nuclear Graphite Notes from

NATIONAL CARBON COMPANY

DIVISION OF UNION CARBIDE CORPORATION, 270 PARK AVENUE, NEW YORK 17, N.Y.

OFFICES: Birmingham, Chicago, Houston, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco. In Canada: Union Carbide Canada Limited, Toronto

NO OTHER MATERIAL HAS SO MANY USEFUL NUCLEAR PROPERTIES

- EXCELLENT STRUCTURAL MATERIAL
- RESISTS CORROSION
- RESISTS THERMAL SHOCK
- EASILY FABRICATED
- HIGH MODERATING QUALITIES
- STRENGTH INCREASES WITH TEMPERATURE RISE

PRECISELY MACHINED GRAPHITE FOR THERMAL COLUMNS

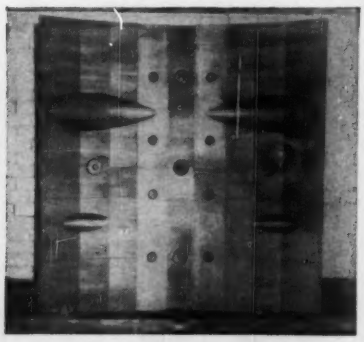
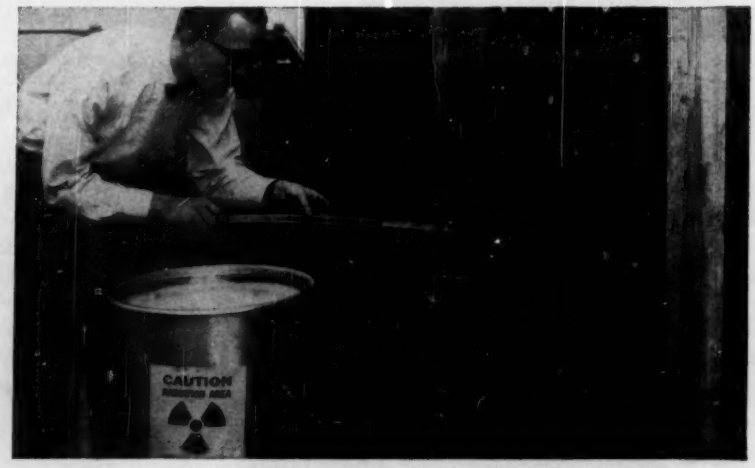


Photo shows inner wall of an 11 foot long graphite thermal column. Graphite was chosen for this installation because it is an excellent moderator of neutrons with low capture cross section.

This wall has 30 major blocks; the other 4 walls have 144 accurately machined blocks each. In all, 1300 precision machined graphite pieces are included in this thermal column. Close tolerances were held in machining each piece.

Many Universities are now using Graphite Moderated Training Reactors



Dr. E. F. Leonard, director of Laboratory Work for Columbia University, inserting a neutron source of plutonium-beryllium obtained from the Atomic Energy Commission.

A recently conducted survey shows that many universities throughout the country are using graphite exponential piles for training the sorely needed nuclear engineers of tomorrow. The survey also points out some of the advantages associated with graphite which are not found in other types of subcritical piles.

Graphite offers longer neutron diffusion (approximately 50 cm) and permits wider fuel rod spacing to assure accurate flux measurements. Also flux distortions are easily determined in graphite piles.

The structural and machineability features of graphite permit students to design and construct the pile. There are abundant experimental data and procedure history available on graphite (it's the oldest type of subcritical reactor) which permit more time for advanced experiments rather than basic fundamental experimentation.

A graphite pile also offers considerable flexibility. It is easy to change configuration, to introduce voids, to accurately position samples, and the pile can be operated as either a bare or reflected system.

Dr. T. J. Thompson, professor of Nuclear Engineering at M.I.T., removing a plutonium-beryllium neutron source from the subcritical nuclear reactor.

"National" and "Union Carbide" are registered trade-marks for products of

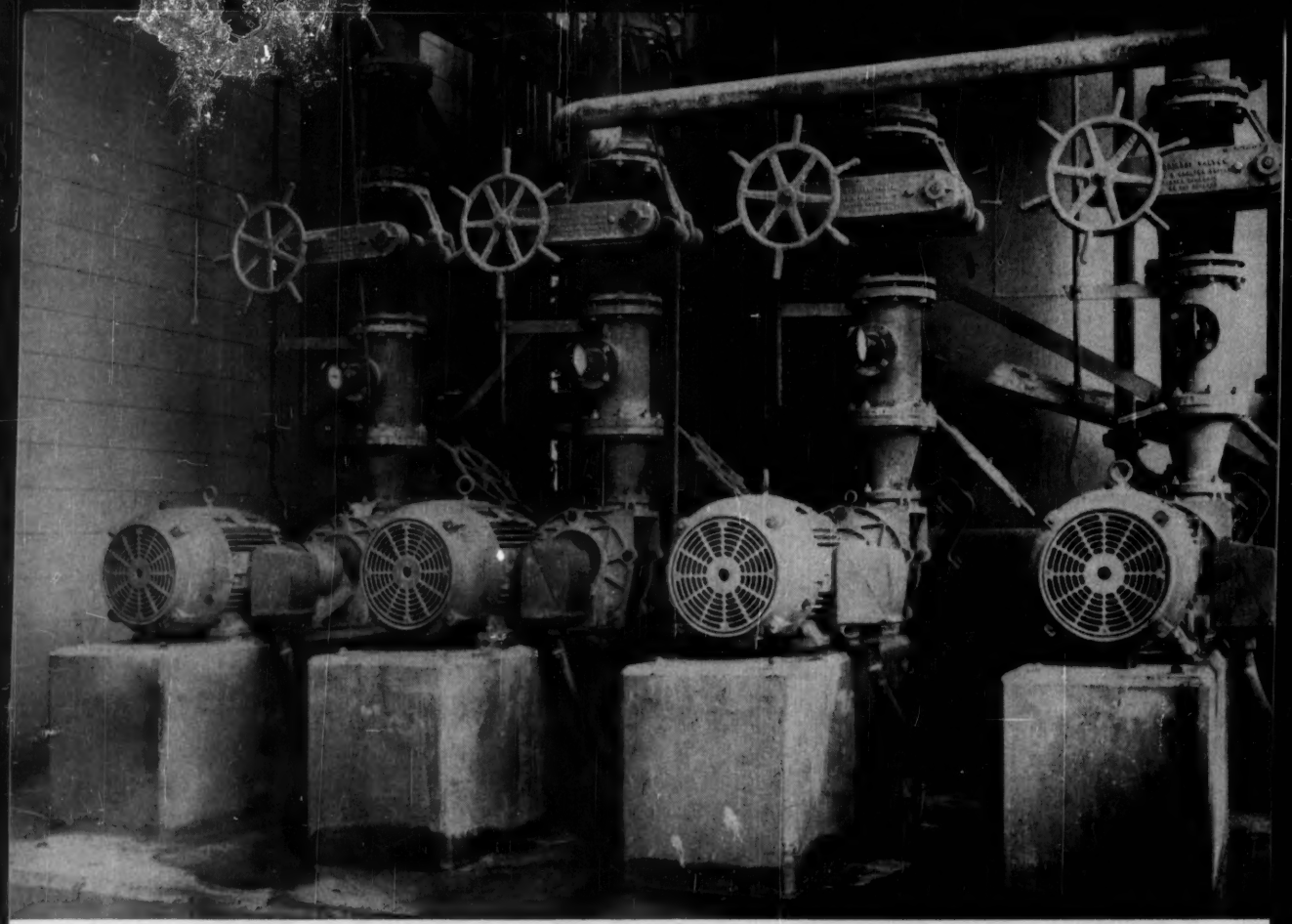
NATIONAL CARBON COMPANY

UNION CARBIDE

IN THE PHOSPHATE FIELDS OF FLORIDA, Virginia-Carolina Chemical Corp. is expanding production facilities of its 40-acre phosphate plant. Engineer and contractor Wellman-Lord Engineering, Inc., of Lakeland, Florida, employed the Westinghouse coordinated project plan for electrical equipment. This single-source facility eliminates many of the headaches usually encountered in equipment installations involving multiple suppliers.

J-96158

HOW TO GROW BIG WITH FEWER GROWING PAINS...



RESISTS CORROSION . . . The new Westinghouse Life-Line® "A" totally enclosed motors installed at this plant have been specifically designed to resist highly corrosive atmospheres created here by sulfuric acid (wet process) and phosphoric acid. Basic protection is provided by heavy cast-iron frames, brackets and conduit boxes. Other Life-Line "A" features include nonsparking, noncorrosive fans protected by heavy cast-iron hoods, flingers which protect against moisture entry, and high integrity Westinghouse insulation system. The four 50-hp TEFC motors (above) are on the fluorine recovery unit.

J-96158-2

SAFER . . . Westinghouse metal-clad high-voltage switchgear provides unusual safety through interlocking devices and full steel barriers in a completely compartmentalized design.

LASTS LONGER . . . These two Westinghouse 800-hp synchronous motors arrived at the job site *before* the promised delivery date. They will drive the ball mills for phosphate rock grinding. Exclusive Westinghouse Thermalastic® insulation tests out at 20 times longer life than other insulations. Insulation life expectancy is estimated to be 100 years.

LESS UPKEEP . . . Westinghouse Ampgard* high-voltage starters simplify and reduce maintenance. Contactors are completely serviceable without being removed from the starter. Tilt-out arc chutes of contactor permit immediate inspection and quick replacement.

*Trade-Mark

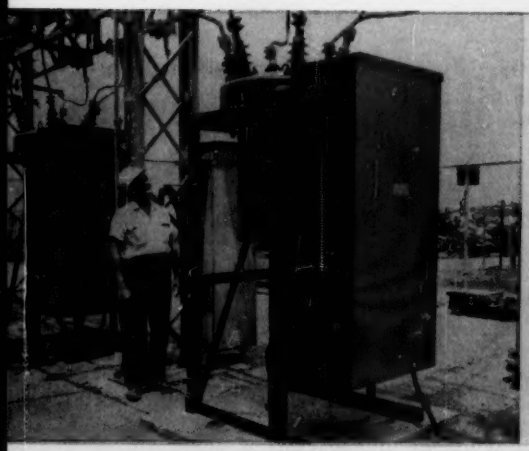
WESTINGHOUSE SINGLE-SOURCE RESPONSIBILITY MEANS LESS PAPERWORK, UNDIVIDED RESPONSIBILITY, FULLY COMPATIBLE EQUIPMENT

Two hundred and two motors of various ratings—five assorted transformers—two 14.4-kv oil circuit breakers—two indoor switchgear units—enough starters to fill four control center rooms. This is the apparatus involved in the electrical system for Virginia-Carolina Chemical Corporation's new phosphate plant in Nichols, Florida.

Putting such a complex system as this on the line could pose formidable problems in coordinating purchasing and deliveries. But both Virginia-Carolina Chemical Corp. and Wellman-Lord Engineering, Inc., of Lakeland, Florida, decided from the beginning to utilize Westinghouse single-source responsibility. Here were the benefits: *A single standardized line of coordinated electrical equipment . . . a single point of contact . . . a single order number . . . a single individual responsible for price negotiation, delivery, schedules and start-up.* Results: A big reduction in paperwork. Substantial savings in engineering time. Prompt deliveries.

Let us know about your expansion plans. Westinghouse can develop a program to meet your short-range and long-range plans . . . aimed at economy. Why not talk to your Westinghouse representative early in the planning stages? *You can be sure . . . if it's Westinghouse.*

Westinghouse



FULLY PROTECTED . . . George Bunch, Westinghouse Service Engineer, inspects 14.4-kv oil circuit breaker. Automatic reclosing equipment restores service to protect incoming lines or feeder circuits from prolonged and costly outages.

MORE ECONOMICAL . . . One of the two Westinghouse 750-kva transformers at Virginia-Carolina's new Nichols plant. Ratings of the plant's three other Westinghouse transformers are 500 kva, 1000 kva and 2000 kva. These Inerteen®-filled transformers for chemical use offer the many economies of Westinghouse standardization and engineering design advantages based on years of proved experience.

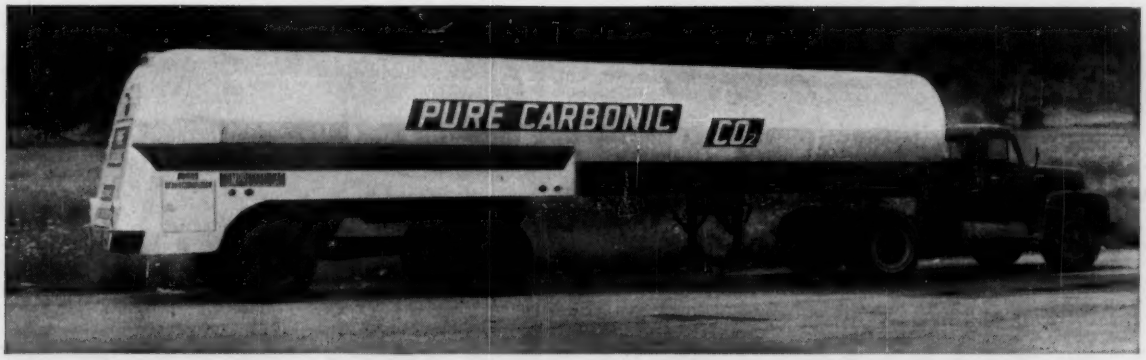
J-96158-3

HIGH-VOLTAGE TEAM . . . Seated at left, W. F. Karns, Wellman-Lord Engineer, goes over plans for expanding Virginia-Carolina Chemical's Charles T. Harding Plant in Florida. Single-source responsibility for negotiation, delivery and start-up of electrical equipment is represented by Westinghouse Sales Engineer W. B. McGuire, seated right. Contributing their specialized knowledge and experience to the $12 million project are, standing left to right, Chief Electrical Engineer J. H. Ham, Chief Field Engineer D. R. Mossberger (both of Wellman-Lord Engineering, Inc.) and Plant Manager W. C. Thomas of Virginia-Carolina Chemical Corp. J-96158-4

Westinghouse

IF YOU'RE PLANNING TO EXPAND, REMEMBER...

WESTINGHOUSE SINGLE-SOURCE RESPONSIBILITY MEANS LESS PAPERWORK, UNDIVIDED RESPONSIBILITY, FULLY COMPATIBLE EQUIPMENT



Hackney insulated transports for controlled or constant temperature applications. Engineered to deliver more miles of service per dollar invested. Built to your specifications, of T-1 steel, or various other steels, alloys, or stainless steels.

Highway, in-plant or high seas

For profitable hauling, Hackney transportation equipment pays off

Wherever a compressed or liquefied gas requires a pressurized transportation vessel, you will find Hackney equipment doing the job—on the highways, within plants or on the high seas. And doing it at a profit to the user!

Every Hackney unit is engineered to meet service requirements, including complete piping, metering and transfer equipment...and temperature controls such as jackets, insulation, heating and refrigeration systems. Compliance with all regulations and highway laws is assured. Our facilities provide the latest equipment and engineering know-how for working all types of ferrous and nonferrous metals, as well as installing insulation, including popular "foamed-in-place" urethane.

Choose from our line of standard equipment or have our engineers design custom units for your special and unique applications. In either case, the Hackney trade-mark on your units is your assurance of complete attention to detail and consistent top quality. Call our representative today or write us direct for details.

Wagons for in-plant movements can be designed for any specific service.

Hackney single-barrel trucks are designed to speed loading and unloading of liquefied compressed gases. Built with all latest safety features and to comply with ICC specifications.

Tank units for land-sea shipment are interchangeable with dry freight containers.

Hackney single- or multi-compartment, noninsulated transports handle liquefied compressed gases such as refrigerants, LP-gas, ammonia, etc.

Pressed Steel Tank Company

Manufacturer of Hackney Products

1447 South 66th Street, Milwaukee 14, Wisconsin

Branch offices in principal cities

COMPRESSED GAS CONTAINERS FROM 1 TO 30,000 GALLONS

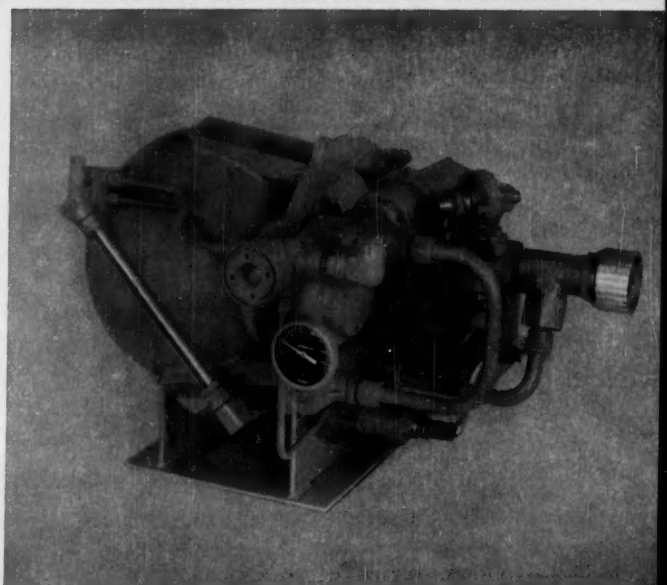
3M COMPANY CHEMICALS THE RAW MATERIALS OF PROGRESS

FLUOROCHEMICALS FAMILY *sets new specs for today's materials and processes*

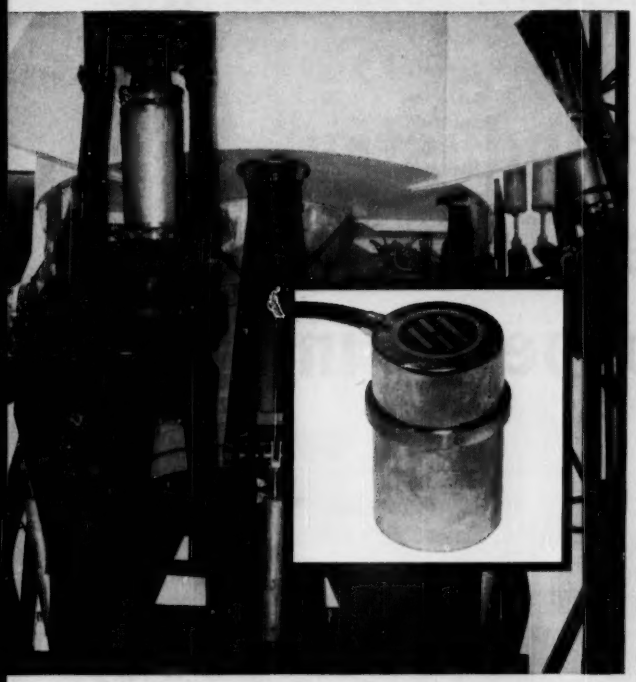
3M specialty chemicals implement better elastomer and rubber processing, new stability in plastics, high corrosion and temperature resistance for many materials

For the increasingly complex jobs facing today's chemical processor, a new and talented family—3M Fluorochemicals—lends a powerful hand. This new *class* of chemicals offers properties that are unduplicated by any other materials to help the processor develop techniques and products that serve well beyond conventionally accepted limits.

In today's chemistry of textiles, paper, packaging, leather, rubber, plastics, metals and structural materials . . . 3M Fluorochemicals add new chemical, thermal and dimensional stability—add flexibility, longevity, strength and functional improvements to many products. And 3M research is still expanding the boundaries of this new chemical frontier. Here are examples of 3M specialty chemicals at work today . . .

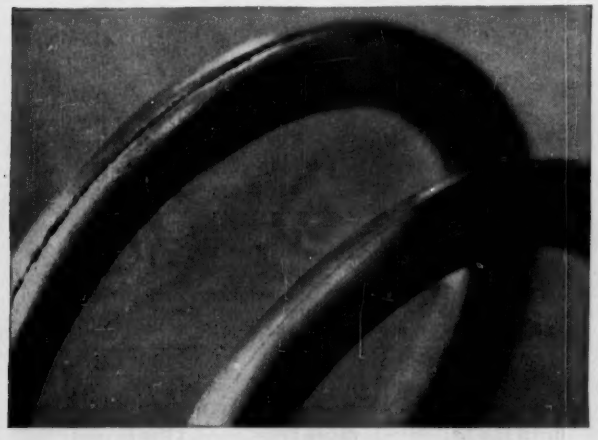


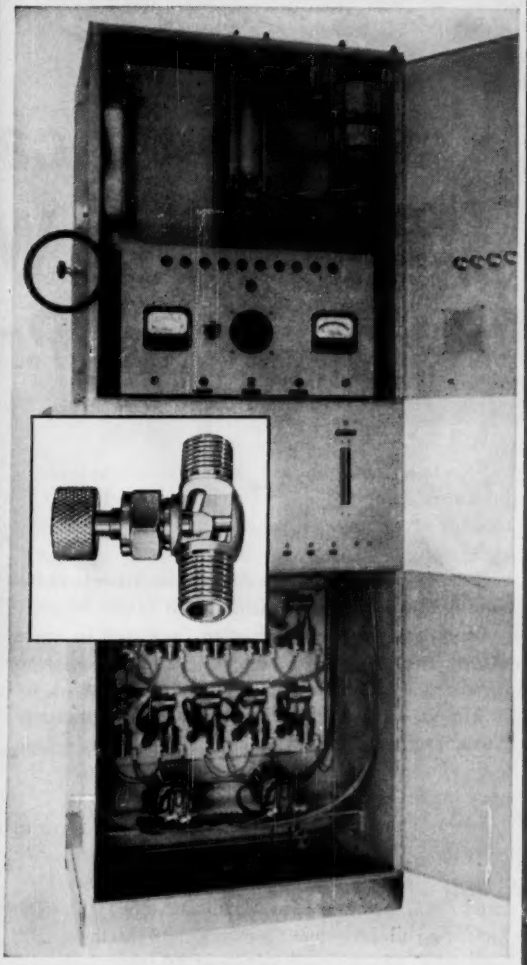
3M BRAND DIELECTRIC COOLANT FC-75 keeps jet bomber's countermeasures system cool. The high heat transfer efficiency of 3M Inert Fluids has proved a big help for designers in miniaturizing electronics gear. These fluids—FC-75 and FC-43—provide high dielectric strength, low solubility, great thermal stability and low pour points. They are highly dense, immiscible and non-corrosive. What can 3M fluids cool off for you?



KEL-F® BRAND OILS are used in guidance gyros to minimize drag and friction on gimbal bearings, since the fluid displaced is the same density as the floating gimbal. Also, the fluid acts as a damping mechanism to cushion against vibration and missile acceleration shock. The "molecular control" possible with KEL-F Oils facilitates careful blending to meet a great range of viscosity and density requirements. Also available as wax or grease. How can they serve you?

NEW FLUOREL® BRAND ELASTOMER 2141, for fluorinated rubber processors, affords an unexcelled Mooney scorch rating that permits faster, more economical cures. Note how Fluorel O-ring, right, is free from defects of other elastomer ring. Fluorel safely permits repeat processing, solves problems involving corrosive materials—withstands 400° F. for continuous service, 600° F. for shorter periods. What can this hard-working elastomer do for you?





KEL-F® BRAND PLASTIC is used in valves handling corrosive gases or liquids. Chemically inert valve tips of this product permit smooth flow of such corrosive substances as ammonia, hydrogen sulfide, hydrocarbon streams, nitrous fumes, hydrogen bromide and ethyl chloride. Valves of this type give positive shut-off, for example, in a series of gas analyzers which monitor gaseous fume leakage in refrigeration, metal plating and treating, petroleum refining and other chemical and industrial plants. How can KEL-F Plastic, unfazed by a hundred chemicals, be of greatest value to you?

Other members of the 3M family of specialty chemicals

CARDOLITE® Brand Resin Flexibilizer for potting and encapsulation • 3M Brand Paint Concentrate for high-strength, non-pigmented primers • CARDOLITE® Brand Friction Components for brake linings, clutch facings, other friction surfaces. For technical data and assistance on any of these 3M products, write 3M Chemical Division, Dept. KAL-120, St. Paul 6, Minn.

"KEL-F", "FLUOREL" and "CARDOLITE" are reg. TM's of 3M Co.

CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

How American Industry Points The Way To Sustained Prosperity in 1961

Something new and very constructive is happening in American industry. It promises to add a major element of strength to business not only in 1961 but right along over the years ahead.

What is happening is essentially this. **American industry is planning to continue to invest heavily in new and better producing facilities in spite of the fact that it has an excess of capacity to produce its present range of products. And, by doing so, business is helping to shape a stronger American economy.** For the continuation of a high level of capital investment by business is one of the most important keys to sustained prosperity.

News of this major new development in American industry is provided by the results of the McGraw-Hill Fall Survey of Business Investment Plans for 1961 and 1962, presented in detail at the right. The McGraw-Hill investment surveys, now in their 13th year, cover a broad cross-section of American industry.

How American industry is aiming to go ahead with a big investment program in spite of its present burden of excess producing capacity is highlighted by the plans of manufacturing companies. The McGraw-Hill fall survey finds that, on the average, these companies are using slightly less than 80 per cent of their producing capacity. They would like to be using well over 90 per cent.

Dramatic New Departure

If historic investment patterns were being followed, our manufacturing companies, with only about 80 per cent of their capacity being employed, would be cutting back new investment programs drastically, and cutting down prosperity in the process. **But — and here is the dramatic new fact — they plan almost no cut-backs in their investment programs.** They plan to invest almost as much (within 3%) in 1961 as they are investing this year. And this year they are investing 19 per cent more than they did in 1959.

There are two major reasons why American industry is unwilling to let its excess producing capacity stall its investment in new facilities until the capacity is more fully used. One is that a lot of this capacity is obsolete and costly to operate. Increasingly rugged competition is creating a strong inducement to replace this antique capacity with modern, more efficient equipment which is widely available.

PLANS FOR CAPITAL SPENDING
(Billions of Dollars)

INDUSTRY	1959 Actual*	1960 Estimated*	1961 Planned	1960-1961 % Change	1962 Planned
Iron and Steel	$1.04	$1.52	$1.37	—10%	$1.18
Nonferrous Metals	.31	.34	.34	0	.32
Machinery	.91	1.15	1.11	— 3	1.11
Electrical Machinery	.52	.62	.68	+10	.63
Autos, Trucks & Parts	.64	.89	.95	+ 7	1.02
Transportation Equipment (Aircraft, Ships, R.R. Eq'pt.)	.39	.41	.37	—10	.35
Other Metalworking	.88	.97	.85	—12	.87
Chemicals	1.24	1.61	1.64	+ 2	1.59
Paper and Pulp	.63	.75	.69	— 8	.53
Rubber	.19	.24	.23	— 4	.20
Stone, Clay and Glass	.53	.63	.56	—11	.55
Petroleum & Coal Products	2.49	2.45	2.52	+ 3	2.50
Food and Beverages	.82	.94	.99	+ 5	.97
Textiles	.41	.53	.42	—21	.40
Miscellaneous Manufacturing	1.07	1.28	1.21	— 5	1.13
ALL MANUFACTURING	12.07	14.33	13.93	— 3	13.35
Mining	.99	.99	.90	— 9	.89
Railroads	.92	1.04	.79	—24	.83
Other Transportation & Communications	4.59	5.20	4.61	—11	4.18
Electric And Gas Utilities	5.67	5.89	6.14	+ 4	6.01
Commercial (1)	8.21	8.61	8.70	+ 1	8.54
ALL BUSINESS	32.55	36.06	35.07	— 3	33.80

*U.S. Department of Commerce, Securities and Exchange Commission, McGraw-Hill Department of Economics.

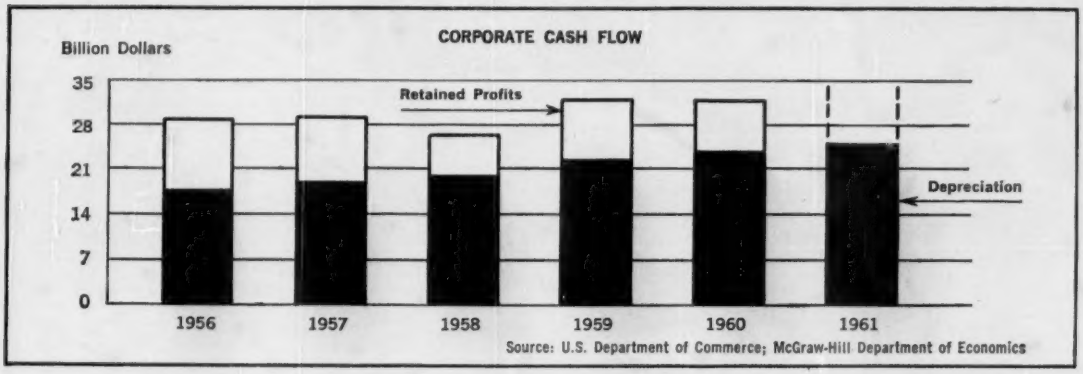
(1) Figure based on large chain, mail order and department stores, insurance companies, banks and other commercial businesses.

"R And D" Paves The Way

The steel industry provides a good case in point. Despite an operating rate of little more than 50 per cent during the last six months, steel companies plan a total investment of nearly $1.4 billion in 1961. And though this is 10 per cent below their capital expenditures in 1960, it will still be the third highest year on record.

incentive and wherewithal to continue a vigorous program of new investment. In addition, if price inflation were to begin surging again, it would eat away the power of depreciation reserves to purchase new plant and equipment.

The allowances now permitted American industrial firms for the depreciation of their producing facilities are lower than those made in any of the industrial



Also, new investment is required to tool up for the manufacture of the new products being spawned by the continuing boom in industrial research and development. This year, we are spending about $13 billion (that's *billion*) for all research and development, about $9.6 billion of it through industry.* And out of it is coming the "know-how" for a veritable flood of new products, processes and equipment, most all of these calling for new producing equipment. Next year, American manufacturers plan to get 12 per cent of their sales in products that did not even exist four years ago.

Key Role Of Depreciation Reserves

A major reason why American industry can combine the desire to carry out big new investment programs with the necessary financial capacity to do it is to be found in the growth of its reserves for depreciation. This year, (1960), business has been in a squeeze between costs and the prices it could get for its products. This cost-price squeeze has reduced profits sharply. The total of profits for the year will be down about 5 per cent.

Allowances for the depreciation of existing plant and equipment, however, have continued to rise. The result is that the so-called cash flow of corporations (their retained profits plus their allowances for depreciation) is the same this year as last. And this cash flow, shown in the chart above, makes a decisive contribution to financing new investment.

Inflation Would Be Deadly

If the sort of profit squeeze that has prevailed this year were to become chronic, it would blight both the

countries with which we are in increasingly tough competition. More adequate allowances would speed up the job of modernizing American industry. An earlier McGraw-Hill survey indicated that it would cost only slightly less than $100 billion to bring our nation's plant and equipment up to date.

But at this juncture, American industry's eagerness and capacity to maintain a high level of investment capital is adding a great new element of constructive strength to the nation's economy.

---

*The significance of this boom for American industry is analyzed in a new McGraw-Hill book, "The Research Revolution" by Leonard Silk, Economics Editor of BUSINESS WEEK. Together with other new business investment trends the "R & D" boom also constitutes a key part of another new McGraw-Hill book, "New Forces in American Business" by Dexter M. Keezer and associates — the November selection of the Business Book Club.

This message was prepared by my staff associates as part of our company-wide effort to report on major new developments in American business and industry. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or part of the text.

Donald C. McGraw

PRESIDENT

McGRAW-HILL PUBLISHING COMPANY

Performance

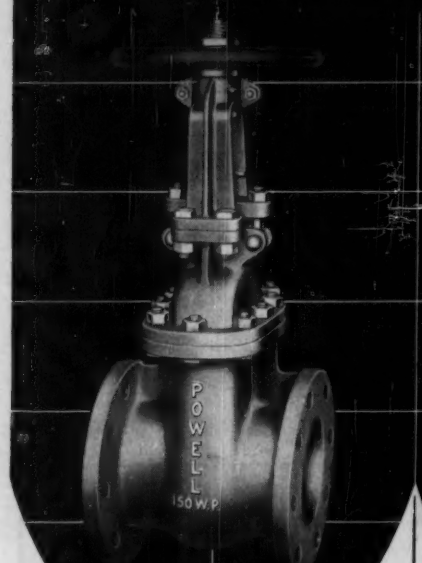


Fig. 2453SG—Large Stainless Steel Gate Valve for 150 pounds W.P. at 500F. Bolted flanged bonnet. Outside screw rising stem and yoke. Interchangeable, fully guided solid or split wedge discs.

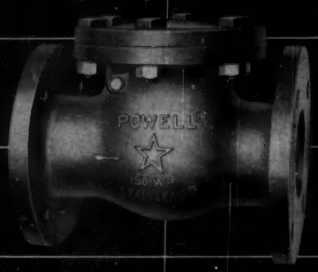


Fig. 2433SS—Large Stainless Steel Swing Check Valve for 150 pounds W.P. at 500F. Bolted flanged cap. Flanged ends. Full unobstructed flow through when wide open.

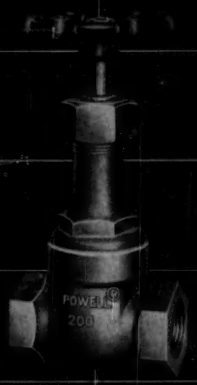
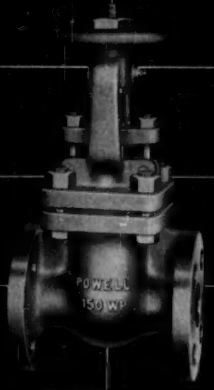
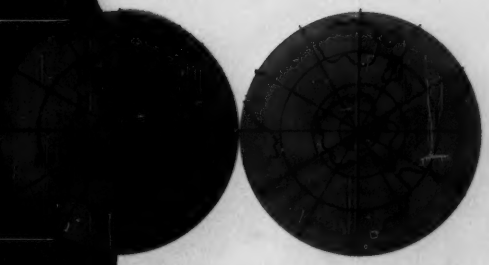
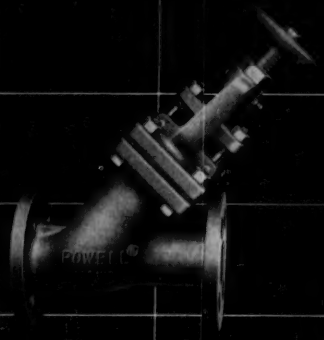


Fig. 1832—Stainless Steel Gate Valve for 200 pounds W.P. at 500F. Screwed-in bonnet. Inside screw rising stem. Interchangeable, fully guided solid or split wedge discs.





Corrosion-Resistant



Powell Corrosion-Resistant Valves are expressly designed and made to control the flow of acids, alkalies, organic solvents, gases and many other corrosive fluids. Today—in chemical and process plants everywhere they are giving long, unfailing service combatting corrosion, erosion, heat and wear.

All types of these valves are available—in stainless steel, nickel, Monel metal*, Hastelloy† Alloys, aluminum and other alloys — to satisfactorily meet any flow control requirement where valve destroying elements are encountered.

So—your industry's fluid handling problem—no matter how tough—can be solved with the right Powell Valve. Ask your Powell Valve distributor (there's one in all major cities) for complete information and literature, or write directly to us.

*Registered trade name of The International Nickel Company.

†Registered trade name of The Haynes Stellite Company.

Fig. 2491—Stainless Steel Gate Valve for 150 pounds at 500F. Bolted flanged bonnet. Outside screw rising stem and yoke. Fully guided solid or split wedge discs.

Fig. 2107—Stainless Steel "Y" Valve for 150 pounds W.P. at 500F. Bolted flanged bonnet. Outside screw rising stem and yoke. Also available with screwed or socket welding ends.

Powell

world's largest family of **valves**

THE WM. POWELL COMPANY
Dependable Valves Since 1846
Cincinnati 22, Ohio

Burst-test for cylindrical-pressure vessels fabricated from USS 9% Nickel Steel, cooled to —320°F, then pressurized to bursting. This one was quenched and tempered—not stress relieved.

Same vessel after bursting at a pressure of 2,160 psi—almost 6 times the design stress of 370 psi.

Operation Cryogenics—Success story of USS

Destruction tests on welded tanks holding liquid nitrogen prove that vessels made from quenched and tempered or double normalized and tempered 9% Nickel Steel, *without* post-fabrication stress relieving, equal—and often exceed —the performance of vessels made of the same steel, which are stress relieved after fabrication.

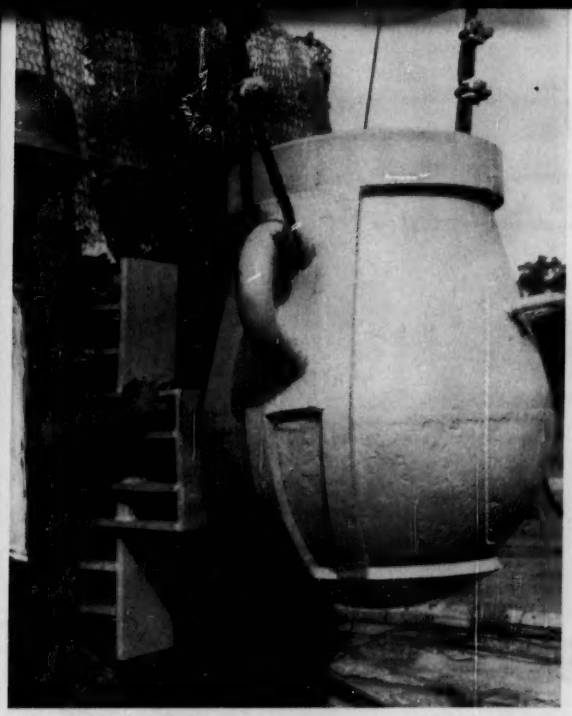
Recently, a series of impact and burst tests, known as "Operation Cryogenics," were performed on 9% Nickel Steel pressure vessels at the Fairless Works of United States Steel. The science of cryogenics, involving the development and practical utilization of materials in extremely low-temperature service, has assumed major importance in industry and in national defense. Much preliminary and advanced development work has been done cooperatively by The International Nickel Company, Inc., The Chicago Bridge & Iron Company, and United States Steel Corporation.

Objectives of "Operation Cryogenics" were to demonstrate (1) the suitability of 9% Nickel Steel, quenched and tempered or double normalized and tempered, in the as-welded condition (not stress relieved), for very low-temperature use; (2) the excellent properties of quenched and tempered 9% Nickel Steel; (3) the ductile behavior of 9% Nickel Steel in the as-welded condition during enforced failure at very low temperature; (4) the behavior of 9% Nickel Steel in the stress-relieved condition for very low-temperature use.

Test conditions: Two basic types of vessels were tested—rectangular vessels 8 feet square and 6 feet high simulating a type that might be used for shipboard transportation of liquefied gases, and cylindrical vessels 4 feet in diameter and 13 feet long with hemispherical heads such as are used for land-based storage and transportation of liquefied gases. All vessels were welded from economical 9% Nickel Steel plate $\frac{3}{8}$" thick, from the same heat of steel.

A total of nine vessels was built for the test. Five were made from 9% Nickel Steel plates and forgings in the quenched and tempered condition (QT) and four in the double normalized and tempered condition (NNT). Further, six of the vessels were tested as welded (AW), without any heat treatment after fabrication. Three were stress relieved (SR).

Impact test results. Impact testing of the three rectangular vessels, refrigerated with liquid nitrogen to –320°F, illustrated that 9% Nickel Steel vessels are capable of undergoing extensive plastic deformation even at extremely low temperatures. The vessels were repeatedly impacted both under pressure and without pressure by blows exceeding 80,000 foot-pounds. One quenched and tempered vessel did not fail, despite 7 impacts. Results clearly indicated the ability of quenched and tempered 9% Nickel Steel vessels in the as-welded condition (not stress relieved) to withstand impacts far beyond any which are likely to occur in service.



4340-pound wrecking ball used in striking rectangular vessels from varying heights.

Impact Test—Rectangular vessel of 9% Nickel Steel quenched and tempered but not stress relieved, refrigerated to —320°F. Withstood severe impact of 82,460 foot-pounds and did not fracture, proving superior strength and toughness of the steel.

9% Nickel Steel Tanks punished at -320°F.

Burst test results. The cylindrical vessels were designed for 370 psi internal pressure (hoop stress in shell equal to 23,750 psi). These vessels were refrigerated to -320°F with liquid nitrogen and pressurized to failure. *The burst pressure for all vessels was at least four times the design pressure of 370 psi and one of the non stress-relieved vessels didn't burst until 2,300 psi.*
(See Table I)

These tests prove that USS 9% Nickel Steel has the high strength, toughness, and weldability needed for low-temperature pressure vessels.

We urge you to consider USS 9% Nickel Steel for economical low-temperature vessels. For the complete story, write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS is a registered trademark

BURST TESTS 9% NICKEL STEEL CYLINDRICAL VESSELS

	PC-1	PC-2	PC-3	PC-4	C-5	PC-6
Heat Treatment	QT	NNT	QT	NNT	QT	NNT
Test Condition	AW	SR	SR	AW	AW	SR
Temp. of Vessel (°F) at start of test	—308	—320	—320	—320	—320	—322
Temp. of Vessel at Failure (°F)	—304	—320	—311	—310	—302	—314
Burst pressure (psi)	2,275	1,550	2,125	2,300	2,160	2,100
Burst stress (psi)	135,510	92,920	129,800	135,730	132,500	129,100

TABLE I. Complete data are shown for burst testing of the cylindrical vessels. In each test, the vessel was filled with liquid nitrogen, supply valves were closed, and pumping continued to build up pressure to bursting point. The data show quenched and tempered (QT) or double normalized and tempered (NNT) vessels in the as-welded (AW) condition withstood greater burst pressures and stresses than did the stress-relieved (SR) vessels.

IMPACT TESTS 9% NICKEL STEEL RECTANGULAR VESSELS

	PR-1	PR-2	R-3
Heat Treatment	QT	NNT	QT
Test Condition	AW	AW	AW
Impact number	#9 of 11	#5 of 6	#7 of 7
Vessel Temp. (°F)	—293	—317	—308
Height of Drop, ft.	19	19	19
Kinetic energy of 4340 lb. weight (ft-lb)	82,460	82,460	82,460
Impact Velocity of 4340 lb. weight (fps)	35	35	35
Vessel pressure before Impact (PSI)	106	100	0
Total indentation after test (inches)	2.44	1.38	3.38

Table II. Data are shown only for the impacts which resulted in cracking or fracture of vessels PR-1 and PR-2. The two vessels were subjected to repetitive tests under increasingly severe impact and pressure conditions, leading up to the test which finally enforced failure. Additional impact tests were conducted on the failed vessels to determine further distortion and dimensional effects. For vessel R-3, which did not fail, data are shown only for the last impact.

For *maximum* strength . . . toughness . . . safety

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
National Tube—Pittsburgh
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

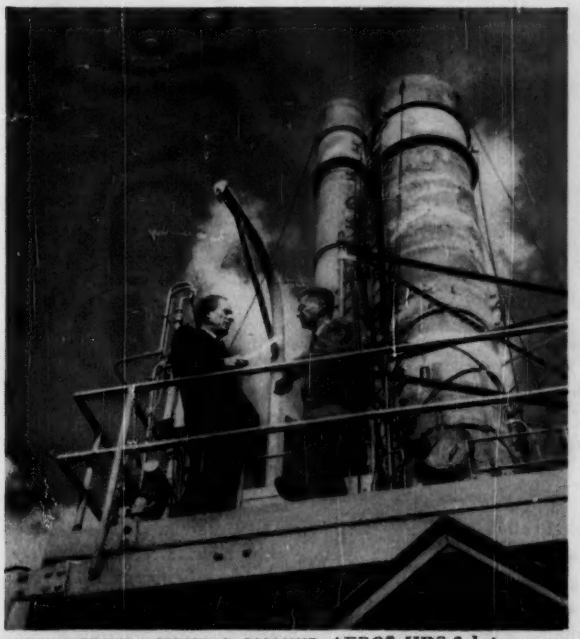
United States Steel

CYANAMID

Chemical Newsfront

MINIATURIZATION OF CAPACITORS AND ELECTROLUMINESCENT LIGHTING are advanced by CYANOCEL® chemically modified cellulose. This remarkable new product is created by treating a purified form of cellulose with highly reactive acrylonitrile. CYANOCEL is currently supplied as a white, fibrous product or 10% solution from which films such as the one shown can be prepared. **(Petrochemicals Department)**

FINISHED: COSTLY FABRIC CARE. Even heavy brocade draperies are machine-washable with a SPECIAL PERMEL PLUS® FINISH. Formulated specifically to fit the requirements of the fabric it protects, this durable finish provides complete home washability, shrinkage control, wrinkle, spot and stain resistance, little or no ironing. **(Textile Chemicals Department)**



NEW HYDROGEN TREATING CATALYST. AERO® HDS-3 brings you the benefits of desulfurization with markedly increased nitrogen and polyaromatics removal over cobalt-molybdenum catalyst compositions. Its applications include treatment of nitrogen-containing naphthas, improving the color of waxes, hydrogenation of cat cracker feedstocks and middle distillates.
(Refinery Chemicals Department)

CYANAMID

AMERICAN CYANAMID COMPANY
30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

NEW SAFETY FOR EXPLOSIVES. CYAMON® S nitro-carbo-nitrate is safe, dependable and especially developed for seismograph exploration. Packaged in hermetically sealed, water-resistant cans, CYAMON S can be quickly coupled by connecting threads to form any column load desired. This new blasting agent requires a primer for detonation – CYAMON S PRIMER, designed to accommodate seismic caps. Both are available in 2"x 1 lb. and 2½"x 1 lb. containers. **(Explosives and Mining Chemicals Department)**

FOR BETTER WORKING CERAMIC FORMULATIONS, try CYANAMER® A-370 modified sodium polyacrylate. Tile cement formulations, grout, mortar, glazes, frits and bisques have distinct advantages when CYANAMER A-370 is used. Of medium molecular weight, CYANAMER is dry and granular in composition and dissolves quickly in aqueous solutions. Available from large scale production at moderate cost. Write for technical data. **(Market Development Department)**

For further information on products in this advertisement wire, or mail this coupon to:

AMERICAN CYANAMID COMPANY **CE-120**
30 Rockefeller Plaza, New York 20, N. Y.
Dept. 6362

Please send me additional information on

- ☐ CYANOCEL® Modified Cellulose
- ☐ CYAMON® S and CYAMON S PRIMER
- ☐ SPECIAL PERMEL PLUS®
- ☐ CYANAMER® A-370

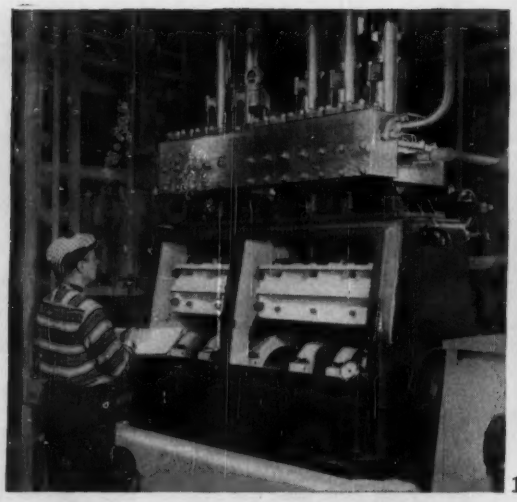
Name_____

Company_____

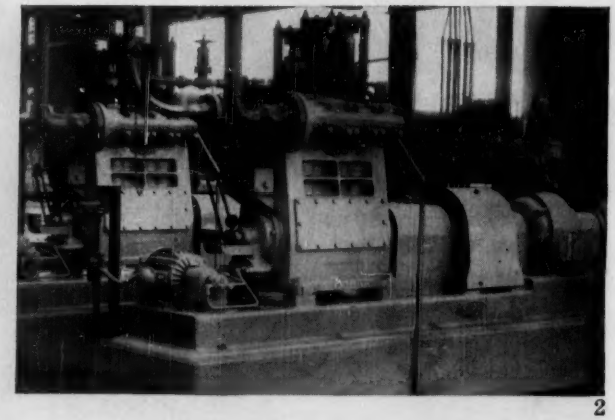
Position or Title_____

Address_____

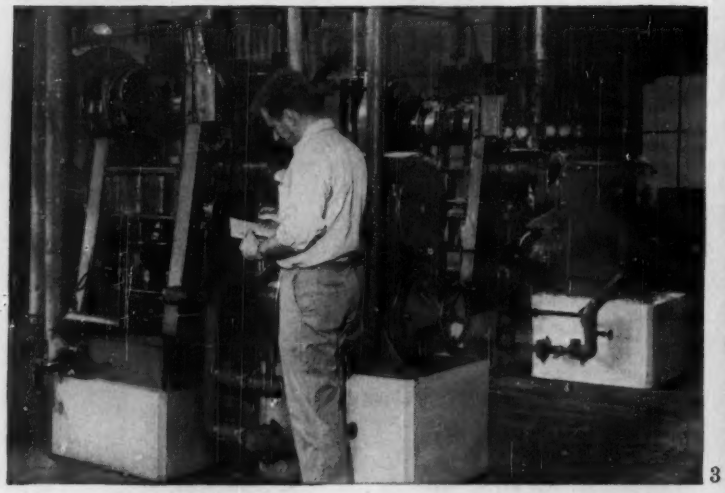
City_____ Zone_____ State_____



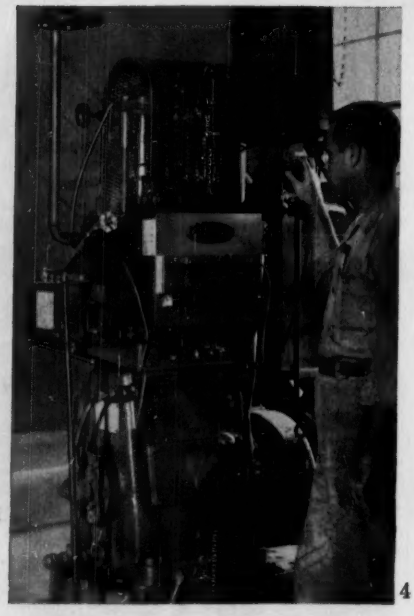
1



2



3



4

ABRASIVE . . . CORROSIVE . . . HIGHLY COMPRESSIBLE . . . VISCOUS . . .

which type of flow is giving you pump trouble?

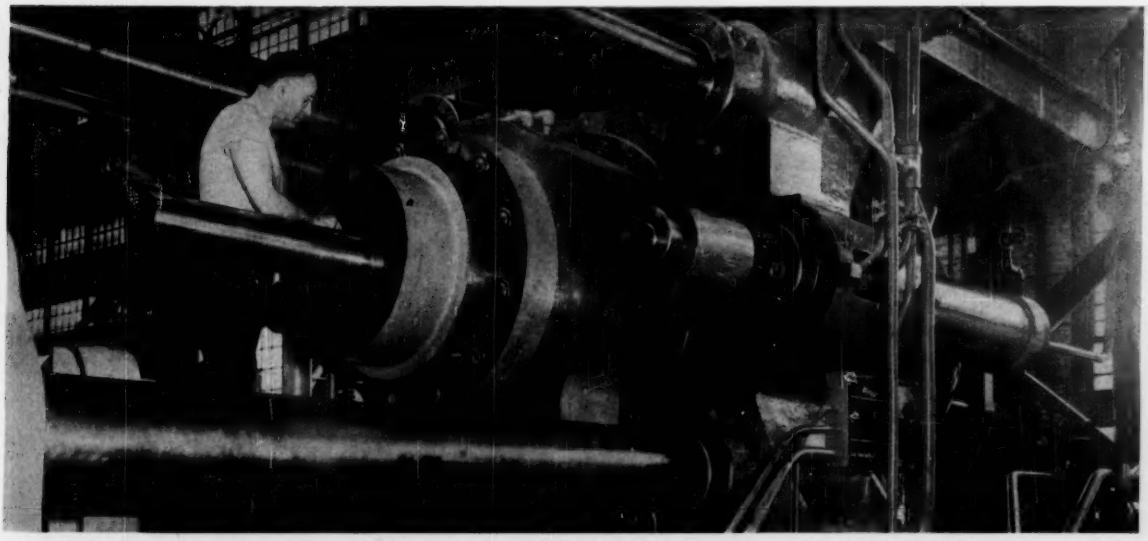
If your pressures are high . . .

If a corrosive, abrasive, viscous or highly compressible liquid is giving your pumps a hard time . . . Aldrich can answer your problem! We *specialize* in pumps for hard-to-handle liquids in the chemical industry . . . working with the widest range of special fluid-end materials and designs in the industry today.

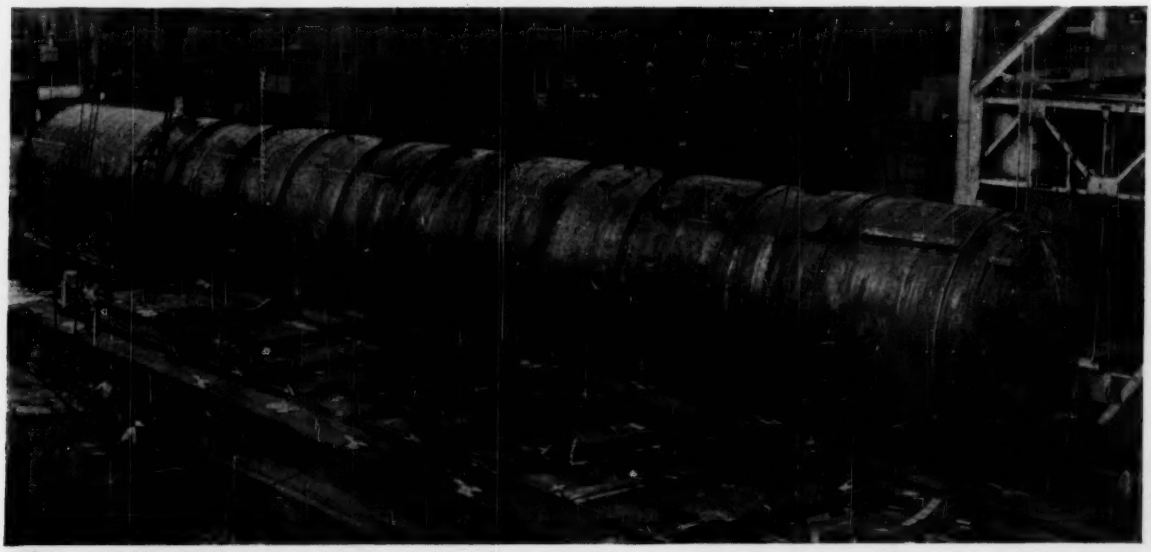
For example: in installation #1 above, an Aldrich pump with stainless steel fluid-ends and special nylon ball valves eliminated severe maintenance problems in handling silica gel at 1800 psi. In installation #2, fluid-ends of 3½% nickel steel have been handling a 50% caustic soda solution continuously for over two years. The reliability record has been perfect. In installation #3, a special Aldrich pump with stainless steel fluid-end has given 8 years of uninterrupted service handling a hot resin ester at 6000 psi. In installation #4, Aldrich pumps with stainless steel fluid-ends have served continuously for over 12 years, pumping hot, corrosive, fatty acids.

Aldrich Pumps range from 25 to 2500 hp.; pressures to 50,000 psi. For additional information, see our insert in *Chemical Engineering Catalog*. For complete data, or help on a specific problem, write Aldrich Pump Company, 3 Gordon Street, Allentown, Penna.

THE TOUGH PUMPING PROBLEMS GO TO ALDRICH



SUN SHIP has what it takes to build . . . . .



for INDUSTRY

We're old hands at building complete machines and special equipment for use in a wide range of industries. For 44 years our large and amply equipped shops have produced items ranging from small tanks to huge fractionating towers, pressure vessels, stills, plate work and special-purpose machinery for the chemical, petroleum and other industries.

Pictured here are a hydraulic press, which was shipped by rail, and a fractionating tower ready for loading on a barge for shipment by water to an oil refinery. They are just two examples of the equipment Sun Ship contributes to many fields, also examples of our shipping facilities.

Because we have all the facilities, we build all equipment right in our own plant, without subletting. Our convenient location on the Delaware River, with direct access by rail and water to all points, assures speedy delivery.

Let Sun Ship solve your machine or equipment problem. Phone or write our Sales Engineering Department.

Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE • SINCE 1916 • CHESTER, PA.

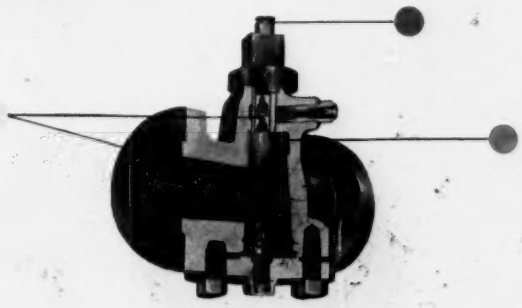
Sven Nordstrom (1881-1951) made world's first lubricated plug valve in 1914. First "lubricant" was a wickless mine candle compressed into the valve by a bolt. Most lubricated plug valves since then have been based on Nordstrom's original ideas.

he tore the wick from a candle

. . . and conceived a better valve for you

When Sven Nordstrom used a mine candle to lubricate his first lubricated plug valve, he created an entirely new valve concept . . . a valve that didn't rely for its effectiveness on wedging metal against metal.

At the time it was patented, in 1916, Nordstrom's valve was the most modern, advanced valve in the world. That is still true —for while the fundamentals have remained the same, Nordstrom's original patents have been continuously improved on through over 80 basically new patents. Over the last 44 years (and millions of valves) each innovation has helped people in a wide variety of industries solve new and even more difficult flow control problems. Look inside the modern Rockwell-Nordstrom valve, shown below, for just a few of the reasons why it will help you solve your flow control problems, too.



PERFECT APPLICATION OF A PRINCIPLE

- Lubricant quickly, easily injected through Rockwell fitting.
- Lubricant travels through Sealdport® system to create powerful seals against leakage and prevent metal-to-metal wear between plug and body . . . note seats never exposed to the line.
- Lubricant hydraulically jacks plug minutely from seat for instant quarter-turn operation.

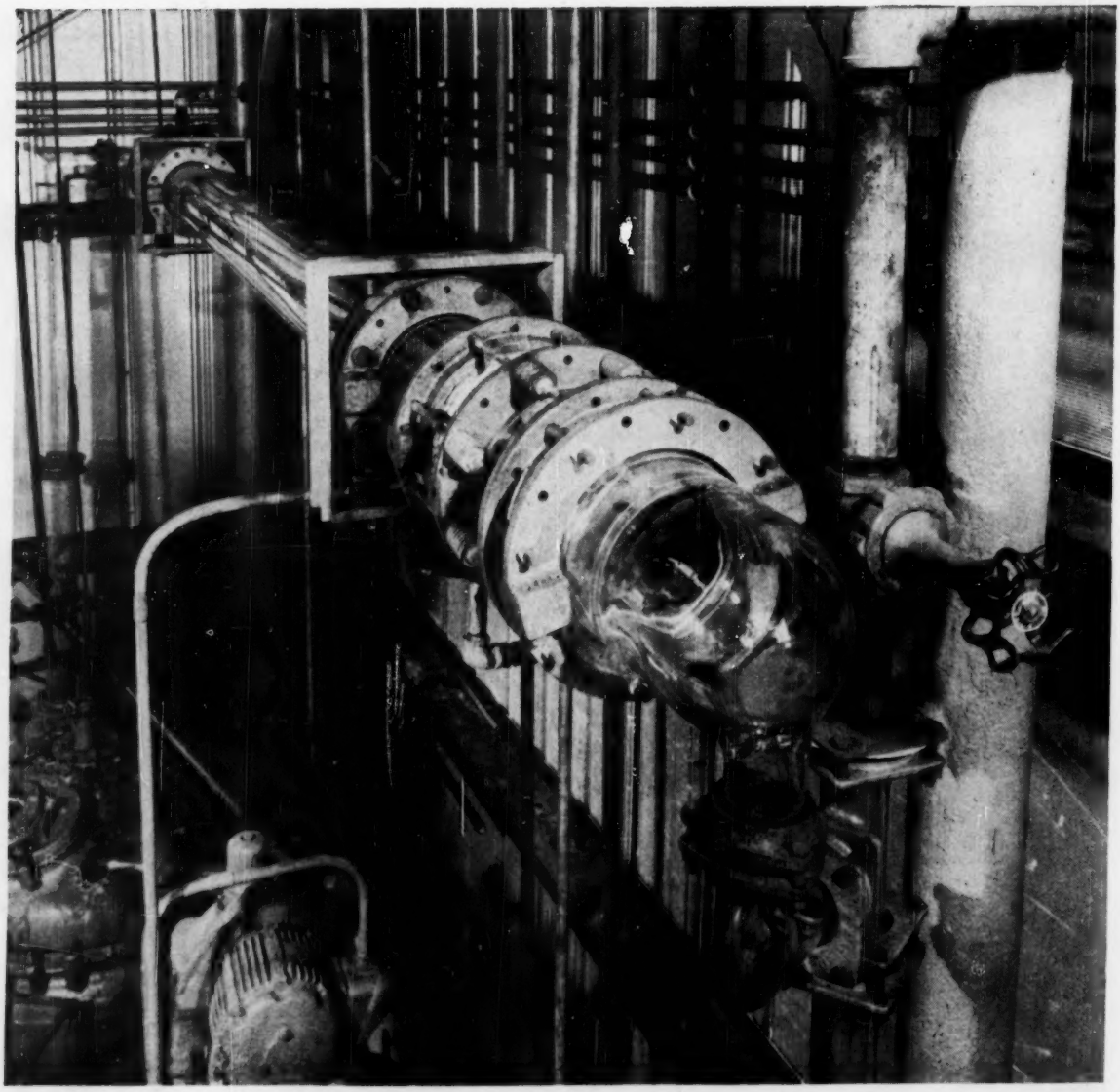
Rockwell-Nordstrom is the original and world's most complete line of lubricated plug valves. Available in sizes from ½" to 36" and pressures to 15,000 lb. For additional information, see your supplier or write: Rockwell Manufacturing Company, Pittsburgh 8, Pennsylvania. Canadian Valve Licensee: Peacock Brothers Limited. If you live outside the USA, write: Rockwell International S.A., Geneva, Switzerland.

Lubrication Makes The Difference

ROCKWELL-Nordstrom VALVES

another fine product by

ROCKWELL



PYREX® HEAT EXCHANGER SERVES 2 YEARS WITHOUT MAINTENANCE ON 70% H_2SO_4 at 120°C

That's hot. And corrosive. But not too severe for PYREX® heat exchangers. In fact, just about any chemical at almost any temperature can be run through a PYREX heat exchanger. With no corrosion. With no possibility of metallic pick-up.

This PYREX shell and tube heat exchanger at Hoffman-Taff is used for four different services in the manufacture of vitamins and other preparations for the feed and pharmaceutical industries: slow distillation 70% sulfuric acid decarboxylation where vapor enters at 120°C; distillation of toluene at 100°C; condensation of water solutions of organic acids under vacuum; ethyl acetate distillation.

If *you* use heat exchangers, you stand to gain a great deal by investigating a PYREX unit. Corning makes shell and tube, jacketed, cascade and candle-type heat exchangers. All of them have established top-notch performance records where corrosion and metallic pick-up are problems. In fact, they've disabused industry of the notion that tubes have to be replaced every few weeks.

Glass compares very favorably with other materials on such factors as heat transfer, first cost and safety. It is by far your best buy on installation and maintenance and as a protection against down time.

If you'd like to weigh the merits of PYREX heat exchangers, we have some bulletins for you. Write to us at 89 Crystal Street, Corning, New York, for PE-33 (Design Manual for PYREX Brand Modular Shell and Tube Heat Exchanger Units).

CORNING GLASS WORKS
CORNING MEANS RESEARCH IN GLASS

ADVERTISEMENT—*This entire page is a paid advertisement* *Prepared by U. S. Industrial Chemicals Co.*

U.S.I. CHEMICAL NEWS

December ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1960

Polyethylene Coatings Cut Fertilizer Loss in Soil

It has been reported recently that coating conventional fertilizers with polyethylene slows down the rate at which they release constituents to the soil. In experiments, a coated fertilizer lost only 5.4% of its potassium, while uncoated fertilizer lost 81.3% in the same period.

Most fertilizer salts dissolve very rapidly in most soils, and, if not used, can be lost. Fertilizer is generally applied when a crop is planted or starts growing, when its nutrient needs are small, and not at midseason, when the nutrients are most needed by the crop. It is felt that by coating the fertilizer, and metering out the nutrients more nearly as plants require them, a more efficient use of fertilizer would result.

New Denaturant Approved For SDA-40 Formulations

The Alcohol & Tobacco Tax Division has just approved a third denaturant for use in specially denatured alcohol (Formula No. 40) — a synthetic organic called "Bitrex," chemically, benzyldiethyl (2:6-xylylcarbamoyl methyl) ammonium benzoate.

"Bitrex" is much more bitter than brucine or quassin, the two denaturants used exclusively in SDA-40 until now. In addition to ⅛ gal. tert-butyl alcohol, only ¼ oz. of "Bitrex" is required to denature 100 gallons of ethyl alcohol, as against 1½ oz. for the other denaturants.

There are now four SDA-40 formulations approved by ATTD. U.S.I. designations are as follows:

SD-40-1	1½ oz. brucine alkaloid
SD-40-2	1½ oz. brucine sulfate
SD-40-3	1½ oz. quassin
SD-40-4	¼ oz. "Bitrex"

Cl_2-N_2 Mix Suggested for Degassing Aluminum Melts

A new treatment has been proposed for removing dissolved hydrogen and included oxides from molten aluminum. It employs a mix of 10% chlorine—90% nitrogen.

In melting and casting aluminum, oxides must be eliminated and hydrogen controlled. Chlorine treatment is regularly used but, in an attempt to eliminate fuming and corrosion problems, nitrogen has been tried. However, results from nitrogen flushing vary from day to day.

Experimenters have determined that 10% chlorine and 90% nitrogen gives the consistent results of chlorine alone, releases no fumes, eliminates corrosion.

U.S.I. Expands Program to Give Handling Help to Sodium Users

New Hydrocarbon Desulfurization Process, Other New Uses Spur Interest in Sodium Equipment, Maintenance, Safety

Because of the interest in new uses of sodium such as U.S.I.'s new, economical sodium process for reducing thiophene levels in hydrocarbons, the company expects increased interest in its program of plant design assistance to sodium users. U.S.I.'s sodium production engineers have often helped customers and prospects set up and maintain trouble-free operation in plants using sodium. The company now plans to make more plant men available to work on these problems.

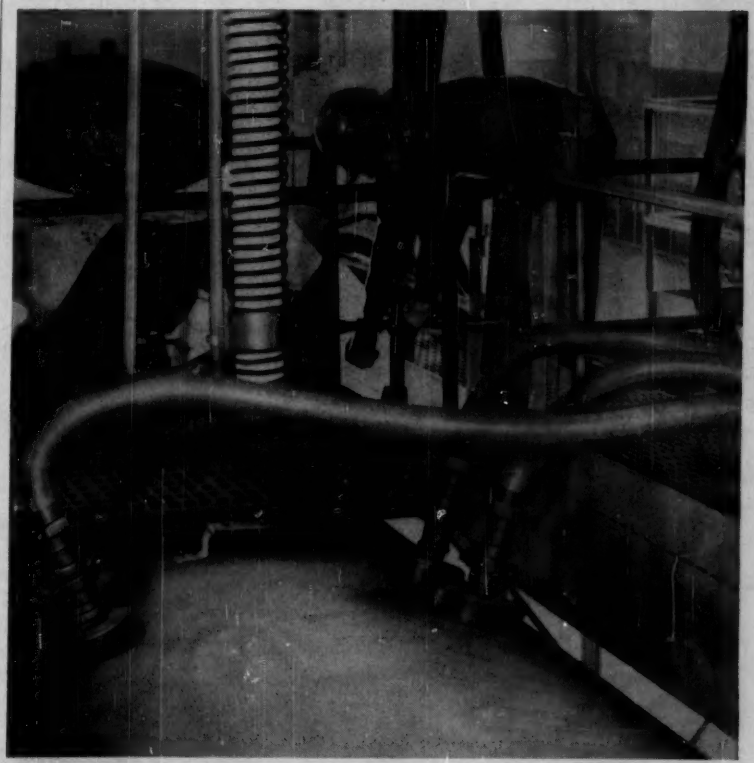
Layout and Equipment Assistance

Engineers from U.S.I.'s Ashtabula, Ohio, sodium plant can and do provide engineering help in laying out sodium processing and handling equipment. Typical examples are tankcar unloading stations, solid pack melting layouts, design and layout information on sodium lines, filters, pumps, valves and metering.

MORE

New Caustic Soda Book Just Issued by U.S.I.

Facts about caustic soda are covered in a new, 36-page booklet now offered by U.S.I. Up-to-date, practical information on properties, applications, methods of analysis, shipping, handling procedures, and safety measures is included. There are many graphs and tables, an extensive bibliography, and a complete index. For your copy, address Technical Literature Dept., U.S.I. Chemical News, 99 Park Ave., N. Y. 16, N. Y.



In typical sodium tankcar unloading station, designed by U.S.I. plant engineers, molten sodium discharges through vertical pipe heated by induction coil. Hot oil flows into tankcar coils through metal hoses.

CONTINUED

Sodium Handling

The Ashtabula men, from their own production experience, have the specialized knowledge required for selecting proper types of pipe, valves, flanges, gasketing materials, line heating devices, and other accessories. On many occasions, they have been able to give a customer the maximum of troublefree operation by sharing this experience with them.

In addition to offering initial plant design assistance, U.S.I. engineers will trouble-shoot existing sodium handling equipment, and can usually make recommendations that will enable customers to correct troublesome situations at minimum expense.

Safety and Maintenance Instruction

In many instances, safety instructions are needed by customers. The information which U.S.I. plant men have supplied on the safe handling of sodium, and disposal of scrap, to customers' safety engineers and operating personnel has proved very helpful. This has done much to allay the fears some people seem to have in handling sodium.

One of the most common aids to customers is instruction in the cleaning of sodium drums, valves, fittings, pipe lines and filters. Very simple procedures are involved, but they must be seen at first hand to minimize problems.

Customers often require assistance in the repair of sodium valves and other process accessories involved in the handling of sodium. Here again U.S.I. plant men are able to make recommendations and supply definite information and specifications.

U.S.I. also makes available a comprehensive brochure, "Handling Metallic Sodium on a Plant Scale," to help customers and prospects with processes involving the metal. The company recommends that this brochure be studied first, after which the U.S.I. sodium plant engineers can be consulted on handling problems.

Role of Patent Department In Chemical Research Stressed at ACS Symposium

In a "Planning for Research" Symposium held by the ACS Division of Chemical Marketing and Economics on Sept. 13, Dr. Janet Berry, Manager of U.S.I.'s Patent Department, discussed how close cooperation between Research and Patent Groups can assure best results from a company's research and development program.

In the initial planning stage of a project, Dr. Berry pointed out, a Patent Department *informed of the plan* can search patents and literature thoroughly to acquaint research management with all of the prior art. This prevents costly duplication of work, and provides a complete foundation on which the research group can build. The savings in time and money can be enormous.

In the active laboratory stage, Dr. Berry emphasized, Research can not always know just what should be patented. If complete reports on *all* developments are sent to the patent group for evaluation during this stage, the patents applied for can be of greatest value to the company.

In the final commercialization stage, Dr. Berry concluded, further benefits can be obtained by reporting all design or process changes during scale-up to the Patent Department. These changes can then be examined for further important innovations which may be patentable.

Dr. Berry

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U.S.I.

New anti-static spray suggested for use during printing and converting of plastics, paper, textiles; during chemical processing; on instruments, etc. Said to chemically neutralize static generated from atmosphere or friction. **No. 1660**

Infrared spectrophotometers, gas chromatography instruments and accessories now being leased to users on three-year basis, after which users may renew lease or buy instruments at small percentage of original cost. **No. 1661**

Fertilizer-grade ammonium nitrate is subject of new manual now available at nominal cost. Covers recommended procedures for proper packaging, handling, transportation, storage—at all stages from manufacturer to consumer. **No. 1662**

Advantages of bulk handling of polyethylene resins discussed in new, 24-page booklet. Analyzes in detail—with help of photos, diagrams, charts and tables—economics of bulk handling in differing situations. **No. 1663**

Titanium welding is subject of new booklet now being sold. Discusses best methods for welding piping and tubing by gas tungsten-arc process. Information has been gathered from laboratories, companies, colleges and literature. **No. 1664**

Synthetic magesium silicate covered in new data sheet. Said to be efficient purifying agent for contact filtration refining of organics such as alcohols, aldehydes, esters, ethers, halogenated hydrocarbons, monomers, silicones, syrups, solvents. **No. 1665**

Self-emulsifiable sperm oil, recently developed, is said to give permanent emulsions by agitating 5-10% of product with 95-90% hot or cold water. Offered for cutting oils, textile and leather oils, petroleum additives, etc. **No. 1666**

"Properties and structure of polymers" a new book now being sold. Explains important features of mechanical behavior of polymers in terms of fundamental principles of molecular behavior and structure. **No. 1667**

New phosphating cleaner and metal conditioner reported to remove rust, corrosion, mill-oil in one step; to retard corrosion and oxidation; to deposit new type colorless phosphate coating on surfaces. Very good rinsability claimed. **No. 1668**

New high-melting synthetic wax (M.P. 156°C, 313°F) commercially available. Is hard brown wax with very high flash point and good electrical insulating properties. Insoluble in all solvents at ordinary temperatures. **No. 1669**

PRODUCTS OF U.S.I.

Heavy Chemicals: Metallic Sodium, Anhydrous Ammonia, Ammonium Nitrate, Nitric Acid, Nitrogen Fertilizer Solutions, Phosphatic Fertilizer Solution, Sulfuric Acid, Caustic Soda, Chlorine, Sodium Peroxide.

Organic Solvents and Intermediates: Normal Butyl Alcohol, Amyl Alcohol, Fusel Oil, Ethyl Acetate, Normal Butyl Acetate, Diethyl Carbonate, DIATOL®, Diethyl Oxalate, Ethyl Ether, Acetone, Acetoacetanilide, Acetoacet-Ortho-Chloranilide, Acetoacet-Ortho-Toluidide, Ethyl Acetoacetate, Ethyl Benzoylacetate, Ethyl Chloroformate, Ethylene, Ethyl Sodium Oxalacetate, Sodium Ethylate, Urethan U.S.P. (Ethyl Carbamate), Riboflavin U.S.P.

Pharmaceutical Products: DL-Methionine, N-Acetyl-DL-Methionine, Urethan USP, Intermediates.

Ethyl Alcohol: Pure and all denatured formulas; Anhydrous and Regular Proprietary Denatured Alcohol Solvents SOLOX®, FILMEX®, ANSOL®M, ANSOL PR.

PETROTHENE® . . . Polyethylene Resins

MICROTHENE . . . Finely Divided Polyethylene Resin.

Animal Food Products: DL-Methionine, MOREA® Premix (to authorized mixer-distributors).

U.S.I. INDUSTRIAL CHEMICALS CO.
Division of National Distillers and Chemical Corporation
99 Park Avenue, New York 16, N. Y.

U.S.I. SALES OFFICES
Atlanta • Baltimore • Boston • Chicago • Cincinnati • Cleveland
Detroit • Kansas City, Mo. • Los Angeles • Louisville • Minneapolis
New Orleans • New York • Philadelphia • St. Louis • San Francisco

Top news stories and what they mean to CPI technical decision makers

Chementator

Big equipment sale shows titanium may be outgrowing gimmick phase

Those in the metals industry who maintain that titanium deserves more than a specialty market in the processing industries are heartened by the news that National Lead Co. has ordered 45 all-titanium heater coils for its Sayreville, N. J., and St. Louis, Mo., pigment plants. Some observers say this is only the first of many big-volume equipment applications in wet chlorine, nitric acid and sulfuric acid service.

National Lead will use the heaters in direct contact with sulfuric acid-metallic sulfate environment. Lead-covered copper coils had been used previously, but these became covered with thick sulfate deposits so that heat transfer was effectively blocked and they had to be replaced every nine months. Cost of the conventional coils was about $1,000; the new titanium units will run about $1,500. Engineers say that the new coils should last indefinitely, with a payout time of only 1.3 years.

The titanium heaters are being fabricated by Saffran Engineering Co., East St. Clair Shores, Mich. The firm has developed a unique welding gun that places the required argon blanket over the joint being welded, without the usual cumbersome trailing shield. The heaters consist of eight lengths of 2-in. welded titanium tubing joined into a coil of 120 linear ft., coiled into ten convolutions.

Screw injector starts new trend in plastics molding industry

A radical change in the technology of injection molding seems to have suddenly fired the interest of the U. S. plastics industry. Reason: products molded by the new technique retain, for the first time, the optimum physical and chemical properties of the whole range of thermoplastic polymers. And hard-to-mold materials like Teflon, Delrin, nylon and rigid PVC can be handled as simply as other thermoplastics.

Basis of the innovation is a screw that circumvents the problems created by the poor thermal conductivity of plastics. The screw first plasticizes, then injects, material into the mold. Conventional equipment plasticizes by heating only, uses a plunger for injection.

Friction created by the screw movement drops the polymer's viscosity below that obtained by simple thermal melting. It also spreads heat quickly to achieve a homogeneous melt. Melting temperatures are lowered, and periods of holding pressure, as well as curing and injecting cycle are consequently shortened.

Screw-injection equipment has been available in Europe since 1955 and is now dominant there. First U. S. installations were made only recently by Dynatech Plastics, Los Angeles. Initial aim of the newly formed company: to employ the new technique for custom molding.

In the past half year, U. S. demands on European producers of screw-injection equipment have grown so large that there is now a 6-8-mo. wait for delivery. Martin Usab, Dynatech vice president, predicts that the entire plastics industry will switch completely to the new way of molding. And U. S. equipment makers are becoming aware of this trend, he reports.

Board says "no" to tar sands venture; cites slow crude demand

Alberta's conservation board has rejected the application of Great Canadian Oil Sands, Ltd., for permission to build a $110-million, 31,500-bbl./day plant to extract oil from the region's huge sands reserves (*Chementator*, June 27, p. 55). Major reason for the refusal was the adverse impact that the additional oil would have on markets for crude oil produced from conventional oil wells in the province.

In its decision, the board resolved a question

Why, indeed? As long as you're in a hydrogen area, there's just as much danger of explosion with one piece of equipment as there is with the other.

And the same goes for acetylene areas, too. *And* for all other pieces of electrical equipment in such an area . . . fixture hangers, seals, flexible couplings, junctions, push button stations.

Crouse-Hinds is the only single source for complete systems of UL-listed explosion-proof electrical equipment, no matter what the National Electrical Code Class or Group.

Crouse-Hinds is also your prime source for expert assistance in choosing and applying equipment for hazardous areas. A Crouse-Hinds Field Engineer is always available to help you plan complete protection in flammable atmospheres of gases, vapors or dusts.

Call your Crouse-Hinds Distributor while you're still in the planning stage of building or remodeling. *That's* the time he can really save you money!

**National Electrical Code designations*

CROUSE HINDS
SYRACUSE NEW YORK

OFFICES: Atlanta Baton Rouge Birmingham Boston Buffalo Charlotte Chicago Cincinnati Cleveland Corpus Christi Dallas Denver Detroit Houston Indianapolis Kansas City Los Angeles Milwaukee New Orleans New York Omaha Philadelphia Pittsburgh Portland, Ore. St. Louis St. Paul Salt Lake City San Francisco Seattle Tulsa Washington
RESIDENT REPRESENTATIVES: Albany Baltimore Reading, Pa. Richmond, Va.
Crouse-Hinds of Canada, Ltd., Toronto, Ont. Domex, Mexico City, D.F. Peterco, Sao Paulo, Brazil

put by many in the oil industry: in light of the present oversupply of crude, what need is there for additional oil sources? The board made it plain, however, that it considers eventual commercialization of the tar sands essential and wants to encourage research to establish the technological basis for a tar sands industry. It has already given the go-ahead to research projects of Shell and the Cities Service team (*Chementator*, Sept. 19, p. 90).

Great Canadian had secured contracts with Sun Oil and Canadian Oil to buy the oil extract from its tar sands plant. Sun was to have taken 23,700 bbl./day and Canadian Oil 7,800 bbl./day. Sun president D. W. Ferguson had testified at hearings last summer that the tar sands oil would replace other Canadian oil now purchased by the company.

A 40,000-bbl./day fluid catalytic cracking unit at Standard of Calif.'s El Segundo refinery is now under open-loop computer control. Stancal is using an IBM 7090, employing leased lines to transmit data from the refinery to the computer at its headquarters in San Francisco, 450 mi. away.

Flurocarbon films finish strong in '60, gird for big push in '61

Capping the most active year to date for fluorocarbon films, Du Pont announced last month that it will build a commercial plant at Buffalo, N. Y., to make polyvinyl fluoride film. On stream date: mid-1962.

Early in '60, the company started commercial production of Teflon 100 FEP (fluorinated ethylene-propylene) film at the same site. And it now has the first cementable version of that film.

At mid-year, General Chemical unveiled a new film made from chlorotrifluorethylene and a small percentage of undisclosed polymer. Larger pilot-plant quantities of the film, called Aclar, will be available when the firm's fluorohalocarbon resin plant at Baton Rouge goes on stream early in '61. The only other fluorocarbon films now available are made by fabricators of 3M's film-forming grade of Kel-F resin.

Initial markets in Du Pont's plans for its PVF film—trademarked Teslar—tap the product's resistance to weathering: wire and cable insulation, protective and decorative finishes laminated to metal- or wood-structural materials, glazing and air-supported structures.

At a development price of $5/lb., Teslar still comes a lot cheaper than the firm's $16.50 (and up) Teflon film. As an outdoor finish, Teslar is a little higher priced than baked enamel, but cheaper than anodized aluminum or porcelainized metal. It lasts 15-20 yr. outdoors while Teflon lasts indefinitely. Mylar, an established glazing material, lasts 3-5 yr., costs $1.50/lb. and up.

General Chemical emphasizes packaging applications for Aclar: its see-through properties, impact-, corrosion- and temperature resistance (-320 to 390 F.) make it a candidate for military, chemical and electronic uses. Du Pont's Teflon FEP film aims at electrical applications involving extreme temperatures (—103 to 482 F.) and corrosive atmospheres.

Research Council of Alberta is studying a plan to transport agricultural or manufactured products via pipeline. Key: encase them in a plastic "torpedo" that will move along with the fluid that is flowing through the line. Transit rates of 10 mph. have been obtained in small-scale experiments.

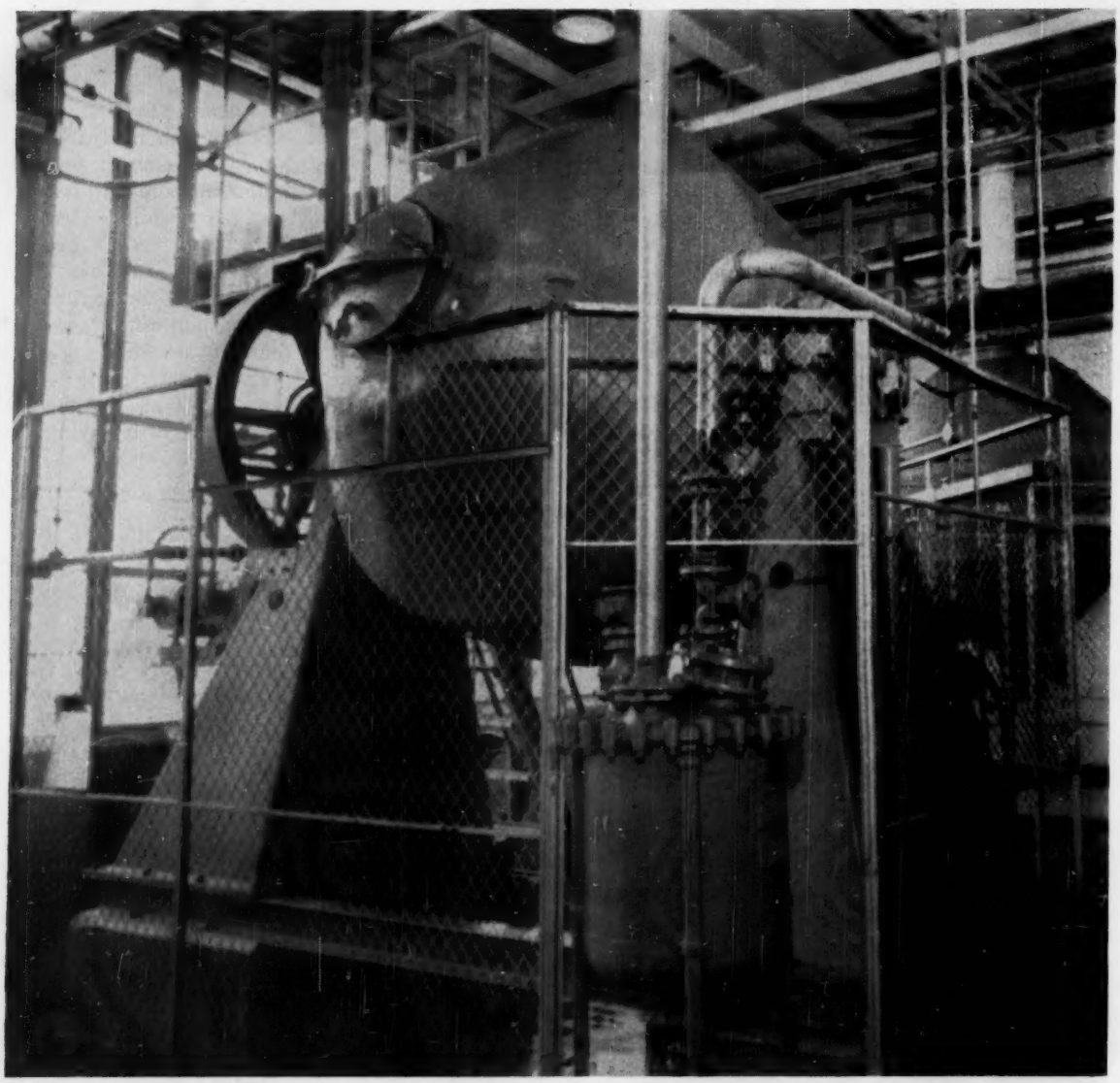
Lure of atom-power economies fires interest in coated fuels

A new fuel concept—uranium oxide particles coated with ceramics—is attracting intensified interest from both the Atomic Energy Commission and industry. Promise of improved high-temperature properties, fission product retention and good neutron economy has prompted the AEC to assign Battelle Memorial Institute a three-year contract to extend its research on coated fuel. And firms such as National Carbon, 3M, Nuclear Metals & Equipment and Mallinckrodt Nuclear are also active in the field.

Ceramic-coated fuel particles have performed satisfactorily at 2,500 F. (vs. about 1,000 F. limit for metal-clad elements) and there is talk of 3,500 F. operation. And ceramic coatings not only protect the fuel from damage at high

(Continued on page 36)

FLUIDICS* AT WORK



HOW MERCK ACHIEVES UNIFORM DRYING

If your process involves bulk drying, you will be interested in how Merck & Co., Inc., handles it at their Flint River plant.

Here, Pfaudler® Conical Dryer Blenders are used to dry a coarse crystalline, acid-salt intermediate, and a fine crystalline, white finished product under closely controlled vacuum and temperature conditions.

Feed goes in with moisture content of approximately 25% and comes out with a residual moisture of less than 1%. The thorough tumbling action achieves a constant, uniformly blended product as evidenced by the quality of the test samples.

And, since product is bulk charged directly into the dryer and discharged into shipping containers, Merck has minimized their product handling.

Resists corrosion. You can use the Pfaudler Conical Dryer Blender with all acids (except HF) and most alkalies without concern over corrosion, since the interior is Glasteel.

Protects purity. This inert glass product-contact surface also protects product purity. Because glass is fire-polished *smooth*, there's little build-up so cleaning is quick and complete.

Versatile. This unit can also be used for impregnating, concentrating, reacting and coating—all in a *single* operation. Such versatility makes further savings possible in capital investment, time, and floor space.

Choice of models. There are four production models with capacities from 2.6 to 165 cubic feet as well as a ⅓ cubic foot lab unit for test purposes. *Ask for Bulletin 963.*

Why the "RA" Reactor is different

The compact silhouette and exterior light-blue color of the recently introduced "RA" Series Reactors hide one of our biggest improvements in this line—the Glasteel 59 interior.

Corrosion resistance. Glasteel 59 offers excellent resistance to all acids (except HF) up to 350°F., and even to 450°F., depending on concentration. Mild alkalies under moderate temperatures are also permissible.

The smooth surface of Glasteel 59 resists build-up of sticky products. You have high heat-transfer rates, increased product yield, fewer shutdowns for cleaning, much longer service life.

Thermal shock resistance. At a vessel temperature of 250°F., the safe recommended temperature differential is now 260°F. A 30% increase.

Abrasion resistance has been increased 20% over previous standards.

Two drives. On the outside, you can select either the TW drive for power requirements to 15 H.P., or the BH if your needs take you up to 60 H.P. and higher. Both are compact, easily installed and maintained.

Mirror-image top head. The symmetrical pattern formed by an equal number of nozzles on each half of the top head means you need only a minimum of headroom and pipe to hook up an "RA" Reactor.

Offset drain. For fast drainage, the outlet is offset and in the direct sweep path of the agitator.

Large and small. Standard "RA" Reactors cover the capacity range from 300 to 4,000 gallons. Custom designs to 8,000 gallons.

Bulletin 988 puts all the details at your finger tips. Write for it.

— NEW BULLETIN —

Glasteel, the Material of Construction

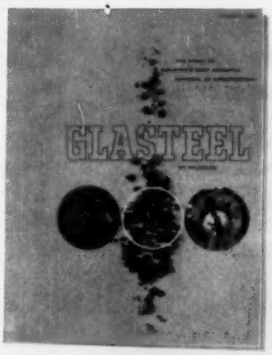
Just off the press is our four-color Bulletin 985, documenting the characteristics of Glasteel 59.

Of its 20 pages, 16 are devoted to *technical data* on specifications, thermal shock, operating temperatures, heat transfer, alkali resistance, acid resistance, and corrosion evaluation facilities.

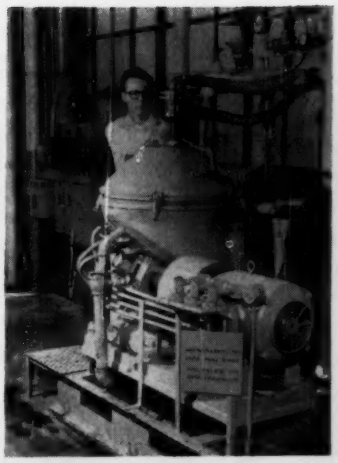
This is the first time all pertinent data on Glasteel have been brought together in a single brochure. The results are impressive. Quite possibly, this bulletin will suggest ways in which you can put this material of construction to use—reducing costs, improving service life of equipment, protecting product purity.

We think you'll find Bulletin 985 a worthwhile addition to your file. Write for your FREE copy.

Please address all inquiries to our Pfaudler Division, Dept. CE-120, Rochester 3, N. Y.



*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.



Yield up, costs down for Johnson's Wax with Titan Centrifuge

When you take the wax from the carnauba palm tree leaf, the wax becomes contaminated with residual leafy particles.

Since S. C. Johnson & Son, Inc., Racine, Wisconsin, uses large quantities of carnauba wax in their many products, the cost of raw materials and clarifying are significant.

Before turning to centrifuging, some refined carnauba was purchased, and considerable crude was clarified using plate and frame filters. Costs were high. Yields were low.

Then the Pfaudler Titan Superjector was installed. Yields of clarified crude increased from 90% to 97%. Consider that the value of refined carnauba is 80 cents a pound, and these savings take on real proportions. Also, the quality of the clarified wax is excellent, so that it's no longer necessary to purchase premium-priced "refined" grade.

Carnauba wax melts at 180°F.; therefore, the Titan centrifuge at S. C. Johnson was specially equipped to maintain a bowl temperature of approximately 240°F.

Other uses. The unique "Selectejject control" in a Pfaudler centrifuge provides broad-range product handling. With continuous feed and solids-only discharge, you get maximum dewatering and concentration of slimy solids. With instantaneous discharge of full bowl contents, coarse, compacting-type granular solids are effectively handled.

See for yourself. Schedule a test of *your* product in Pfaudler's Test Center. For details, write for Bulletin No. 1002.

PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS...the science of fluid processes

temperatures but also retain fission products created by low or moderate irradiation. Keeping these products out of contact with the reactor coolant prevents spread of radioactive contamination to other parts of the system (turbine, compressor and heat exchanger), reducing shielding requirements and capital costs for these sections.

Fuel particles are ceramic coated in a fluid bed. Coated particles, about the size of table salt crystals, are then dispersed in a material such as graphite that can be conveniently shaped into fuel elements by mass production methods.

Battelle's most extensive tests to date have been on alumina-coated uranium oxide. Other coatings under consideration are pyrolytic graphite and beryllium oxide. Still to be determined: upper limit of irradiation that the coatings will sustain. In early tests, material burnup reached 3% before the coatings began to release fission products. Reactors today generally operate at 1-3% burnup levels.

Add one more fuel cell to the burgeoning list: Hoffman Electronics, Los Angeles, has developed a unit that uses a combination of sodium, bromine and mercury to produce open-circuit voltages of 2.8 v. Peak current densities of 10,000 amp./sq. ft. can be obtained for one tenth of a millisecond.

Strategic-Udy process passes test, may wring iron from copper slag

A $30-40-million steel mill at Anaconda, Mont., may result from final test runs at Strategic Materials' Niagara Falls, Ont., pilot plant, where waste copper slag was converted into steel, copper and zinc. The data obtained are being used by Koppers Co., Pittsburgh, to firm up design of a 1,000-ton/day steel plant based on the Strategic-Udy smelting process.

Koppers is designing the mill for Webb & Knapp Strategic Corp., which plans to process several large copper slag piles in the U. S. (*Chementator*, Oct. 19, 1959, p. 95). Several factors make the Montana project attractive: power costs only 0.2¢/kwh.; and water, limestone, coal and iron pyrites are all available nearby. Too, the U. S. and Canada plan to build power dams costing $2 billion on the Columbia River. Company hopes to furnish steel reinforcing bars for the dams and would also try to sell a byproduct from its process (called slag-slag) as a cement additive for high-strength concrete.

Final flowsheet will depend on Koppers' calculations now going on, but the ultimate result will be something like this: limestone, calcined to form lime, is added to copper slag, pyrites and coal, then is fed to an electric furnace where zinc boils off, copper is withdrawn as matte, and iron is partially reduced. Iron and slag are then transferred to a second furnace where coal and lime are added to complete the reduction.

Pig iron is refined to steel in a third electric furnace. Process nets one ton of steel, 25 lb. copper and 150 lb. zinc from 5,500 lb. of slag feed.

Want to be an engineering teacher? Salaries, income are on the way up

The average total income of engineering teachers (from both teaching and other engineering professional work) increased from $9,598 in 1958 to $11,013 in 1960, according to a survey conducted by the Engineers Joint Council. Of the $1,415 rise, $1,007 accrued from salary increase; the balance was an increase in outside income.

Since the average includes everyone from lowest instructor to dean, it's more meaningful to look at income from the various teaching ranks. For instructors, the median total income is now $6,500; lecturers, $7,500; assistant professors, $8,500; associate professors, $10,250; professors, $13,250; department heads, $13,700; and deans, $15,420.

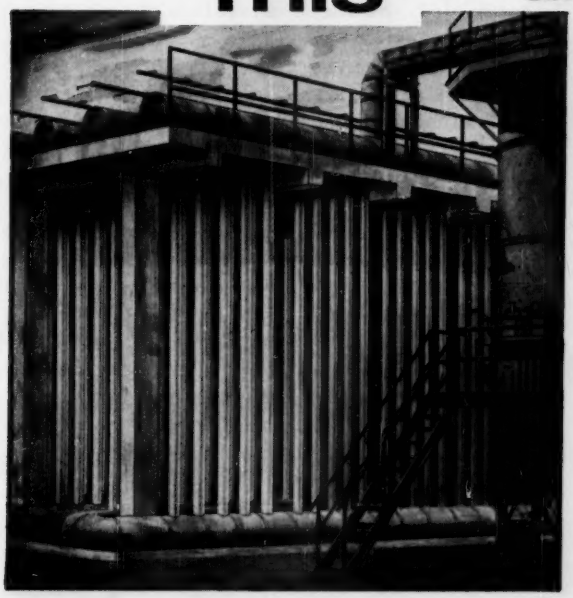
The survey turned up some other items of interest to teachers and would-be teachers. An M. S. is worth about 28% more than a B. S., and a Ph. D. earns 72% more. Also, chances for top income vary with geography. Instructors, assistant professors and deans do best in the Midwest; associate professors and professors are best paid in the Pacific area, department heads draw top pay on both coasts. (These are public-school figures; private schools, for every level above instructor, pay best in the Pacific area.)

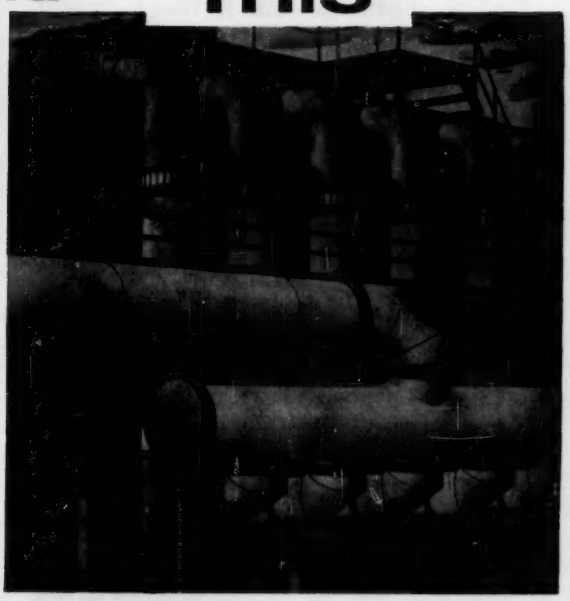
Research to help anthracite dig its way out of market slump

Anthracite coal, reeling from a loss of heating markets that dropped production in Pennsyl-

THE DIFFERENCE BETWEEN

THIS and THIS





is corrosion-resistant

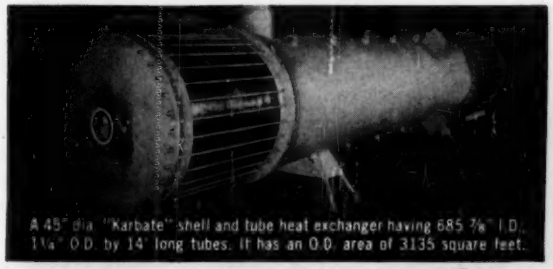
"KARBATE" IMPERVIOUS GRAPHITE HEAT EXCHANGERS!

Today, it doesn't make sense to sacrifice space, money, and minimum downtime by using heat exchangers not having the features of *unsurpassed corrosion-resistance, compactness, and low maintenance of "Karbate" impervious graphite exchangers.* Space was saved, piping simplified, and low maintenance was achieved when the "jungle" of single tube down-draft lead coolers (above left) was replaced by 6 compact "Karbate" shell and tube units (above right).

"Karbate" impervious graphite's high thermal conductivity and complete corrosion-resistance permit these heat exchangers to operate at higher velocities with associated increased heat transfer. This means that "Karbate" units with less surface area can thermally and economically replace larger metal exchangers in which high velocities produce localized accelerated corrosion. In such a case, "Karbate" exchangers with 83% less surface than carbon steel exchangers perform the same cooling job. And, at a total installed cost of approximately $10,000 less than the cost of retubing the corroded carbon steel exchangers with stainless steel tubes.

Actually, "Karbate" units offer unexcelled corrosion resistance at prices, in some instances, up to ⅓ less than many alloy and special metal units in which corrosion is measurable.

If you are considering a new heat exchanger installation, or if you have to replace or add to your present equipment, investigate the advantages of price, excellent corrosion-resistance, and trouble-free performance provided by "Karbate" impervious graphite shell and tube exchangers. For information, write National Carbon Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. In Canada: Union Carbide Canada Limited, Toronto.



A 45" dia. "Karbate" shell and tube heat exchanger having 685 ⅞" I.D., 1¼" O.D. by 14' long tubes. It has an O.D. area of 3135 square feet.

"National", "Karbate" and "Union Carbide" are registered trade-marks for products of

NATIONAL CARBON COMPANY UNION CARBIDE

vania from 56 million tons in 1948 to 19 million tons last year, may fight its way back through research. Considered one of nature's best sources of carbon, anthracite must battle for industrial carbon markets rather than try to compete merely as a source of heat.

In a conference recently held at Penn State U., various researchers pointed out areas in which coal may regain some of its lost markets:

• Finely powdered anthracite is the preferred fluxing agent for sintering and pelletizing iron ores prior to charging to blast furnaces. Up to 2.5 million tons were so consumed this year; by '63, 4 million tons may be required.

• Heat treatment or treatment with chlorine gas at elevated temperatures produces a carbon suitable for carbon electrodes. However, more complete removal of iron, silicon and titanium will have to be accomplished before anthracite becomes a serious competitor of petroleum coke.

• Anthracite can be converted into activated carbon, into metallurgical briquettes, or can be blended with coking coals. And no one is giving up on the black diamonds for fuel—researchers are constantly improving the efficiency of automatic stokers.

Southwest Research Institute, San Antonio, will soon build a several-ton/day pilot plant to prove out the Reid-Townsend process for sweetening and dehydrating sour gases. SwRI will also pilot a variation on the basic process that will remove nitrogen from gas mixtures at near atmospheric temperatures.

New wave of developments in saline water conversion

Solutions of radioactive wastes from nuclear fuel reprocessing—currently creating a critical disposal problem—may prove to be an excellent heat source for saline-water conversion. This conclusion, the latest in a series of water-desalting developments, is contained in an AEC-initiated study being conducted by Chance Vought Aircraft, Dallas, Tex.

Dept. of Interior's Office of Saline Water envisions a process in which waste stocks will be concentrated and calcined, and resulting powder either placed in cylinders, or pelletized and encapsulated. Surface temperature of such a heat source would be 1,500-1,800 F., ideal for flash-distillation or other conversion processes. OSW says a single cylinder might power a 200,000-gal./day conversion plant for 15 yr. Chance Vought has completed preliminary engineering studies. Likely next step: a 200-300-gal./day bench-scale unit.

Also under OSW sponsorship, engineers at Brooklyn Polytechnic Institute are looking at a vapor reheat process for treating sea or brackish water. Vapor from brine is countercurrently contacted with a film or spray of previously distilled water in a cascade of flash stages. Process is said to minimize the equipment and energy required for flash distillation of salt water. Currently on bench scale, project will involve 1-2 yr. of data-gathering before piloting.

Rounding out the news in desalination, Applied Science Laboratories, State College, Pa., has come out with a new freeze process. Key feature is that major steps—ice forming, washing and melting—take place successively in a single vessel, avoiding problems of ice handling. To date, budgetary limitations have prevented OSW sponsorship of the project.

Research and development briefs

Determination of wax in paper by a new technique, developed by the National Bureau of Standards, slashes several hours off the time required by the standard TAPPI test. Weighed paper sample is placed in a bottle and covered with 1,1,1 trichloroethane for 1 min. Solvent is then poured into a weighed beaker, and two more 1-min. extractions are performed. Combined portions of solvent are then evaporated and weight of wax residue determined.

New mothproofing chemicals, called antimetabolites, have been synthesized by researchers at the U. of Calif. Antimetabolites have molecular structure closely resembling insect nutrients, look and taste like food to the pests. But the chemicals actually inhibit amino acid production and cancel out vitamin absorption, thus discouraging the insect invaders. Applied to fabrics, the compounds (one costs only $4/lb., makes 100 gal. of spray solution) would be permanent, nontoxic to humans, cheap and easy to apply.

For More Industrial News . . . 40

When it comes to

MINERAL ACIDS

SULFURIC ACID
Standard: 60° and 66° Baumé, 99% H_2SO_4
Diamond: 66° Baumé
Reagent, ACS

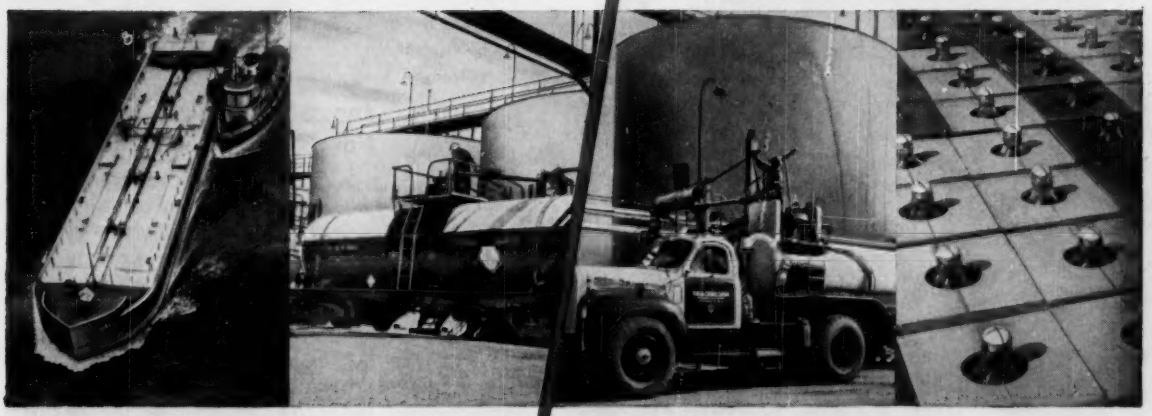
NITRIC ACID
Diamond: 36°, 38°, 40°, and 42° Baumé
Strong Nitric Acid, 95% and fuming grades
Photo-Engravers' Grade
Reagent, ACS

MURIATIC (Hydrochloric) ACID
18°, 20° and 22° Baumé, Standard, Diamond, Crystal and Reagent Grades

HYDROFLUORIC ACID
Anhydrous, Aqueous 70%, and Reagent

PHOSPHORIC ACID
Wet Process, 65% and 75%, Com'l and Fertilizer Grades
Food Grade, 75%
N.F., 85%

MIXED ACID
Varying proportions of Nitric and Sulfuric Acids to meet customers' requirements



Come to

GENERAL CHEMICAL

For 60 years, General Chemical has been the nation's primary producer of heavy acids. General has its own basic raw material sources. Its production facilities include 21* sulfuric plants, 4* hydrofluoric plants, 3 nitric and 3 muriatic acid plants. It operates one of the nation's largest fleets of tank cars, tank trucks and acid-carrying barges, and distributes from key points coast-to-coast. General's production, transportation, service and sales facilities are geared to meet your requirements best, both in quality of product and dependability of service. Write or phone today for information or service.

Basic to America's Progress

Allied Chemical

GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N. Y.

*In Canada: Allied Chemical Canada, Limited

PUMP STANDARDIZATION NEARS...
...ATOM-ENGINE IN SUCCESSFUL RUN...
...JAPAN PETROCHEMICALS TO DOUBLE

Skoal—420 feet down

After a brief stint as a dining room, this gigantic cavern deep under Sun Oil's Marcus Hook, Pa., refinery will serve as a convenient storage tank for 400,000 bbl. of liquefied propane. Hewed from solid granite, the cavern cost 80% less than equivalent surface storage capacity, requires only ½-acre of valuable surface area compared with 25 acres for a tank farm.

Over 2 million cu. ft. of rock were removed to create the vast cave, which is the second of three planned by Sun. The first, in service since 1958, holds 250,000 bbl. butane, as will the third. Sun finds that underground storage facilities require practically no maintenance, have low insurance rates.

MCA Pump Standardization Project Nears Completion

A new standard for horizontal centrifugal pumps will probably be announced next year by the Mechanical Technical Committee of the Manufacturing Chemists Assn., Inc. The standard, now undergoing final approval of committee members, establishes four major points:

- Number: twelve pumps, capacities from 5 to 1,000 gpm., 70 to 250 ft. of head.
- Frames: five sizes, base-to-centerline height on each is standardized to match NEMA motor dimensions.
- Styles: two, frame-mounted with tangential discharge, bottom-casing mounted with centerline discharge. Both have uniform boundary dimensions.
- Stuffing-box dimensions: only three sizes of packing, easy interchange of mechanical seals and stuffing boxes.

The pump standardization project was handled under American Standards Assn. procedures. A standardization effort is also under way in four other equipment areas, although none are as far along as the pump project. These include shell-and-tube heat exchangers, shop-fabricated low-pressure tanks, thin-walled carbon steel pipe, and pressure piping systems.

Successful Test: Atom-Engine Runs 15 Minutes

Atomic rocket engines—long-term hope for manned space ventures—inched closer to reality when the Kiwi-A-No. 3 was run at full power for 15 minutes at Mercury, Nev.

The earthbound device, named after the flightless New Zealand Kiwi bird, shoots hydrogen through an intensely hot atomic-power reactor, which greatly increases the gas pressure. Hot gas is emitted through a nozzle to provide the jet impulse.

Next series of tests will be with Kiwi-B devices, using liquid instead of gaseous hydrogen. Kiwi-B is just one step removed from proto types of engines that can fly. Atomic rocket engines can generate three times as much push as the same amount of chemical fuel.

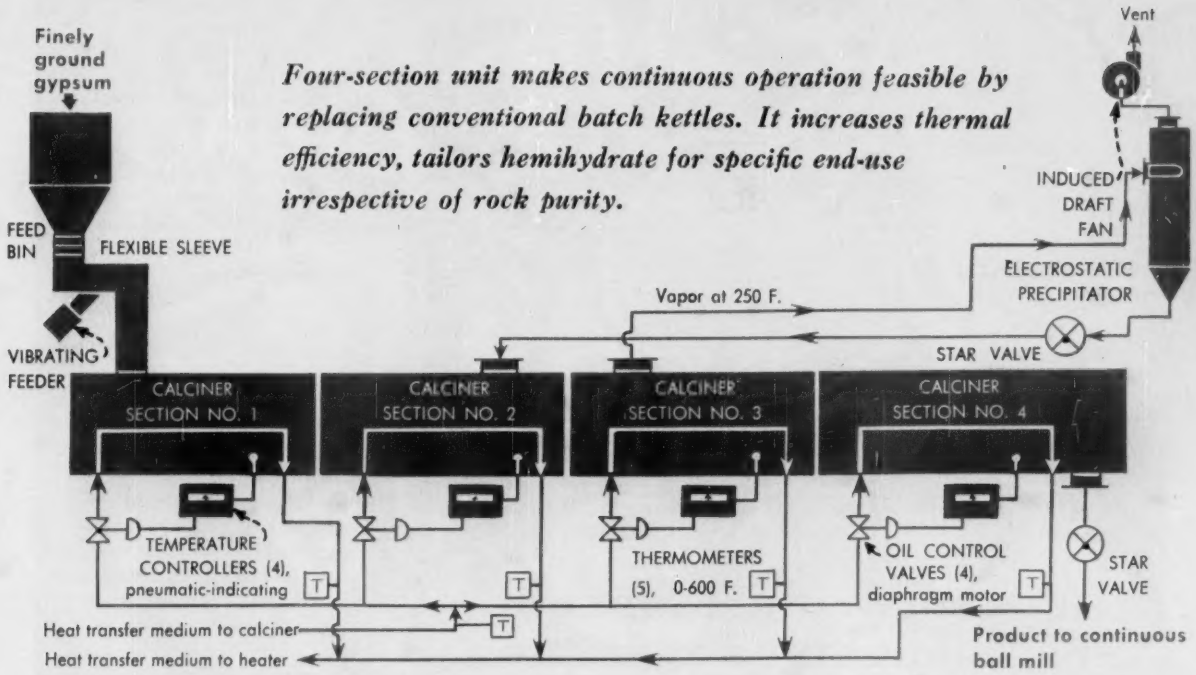
Japan Doubling Capacity For Key Petrochemicals

A new round of expansion in petrochemicals, just officially approved by Japan's Ministry of International Trade & Industry (MITI), will bring the industry's invested capital from $230 million at the end of 1959 to about $840 million by 1963.

By 1963, new projects will raise capacities for each of the following products: acetaldehyde, from 134,700 tons/yr. to 259,700; acetic anhydride, from 25,000 tons/yr. to 48,000; acetone, from 20,000 to 45,100; acrylonitrile, from 26,000 to 58,000; butanol, from 37,300 to 70,300; ethylene oxide-glycol, from 23,600 to 35,400; polyethylene, from 82,000 to 182,500 styrene monomer, from 53,000 to 82,000. Capacity for 30,000 tons/yr. of toluene and xylenes is also planned.

Projects approved in polyethylene are: Sumitomo Chemical, 24,000 tons/yr.; Mitsubishi Petrochemical, 25,000 ton/yr.; Mitsui Petrochemical (joint venture with Du Pont), 24,500 tons Nitto Chemical (joint venture with Union Carbide), 27,000 tons.

Only two styrene projects—11,000 tons/yr. for Mitsubishi Petrochemical, $18,000 tons for Ashi-Dow—were approved.



Four-section unit makes continuous operation feasible by replacing conventional batch kettles. It increases thermal efficiency, tailors hemihydrate for specific end-use irrespective of rock purity.

CALCINER STREAMLINES GYPSUM PROCESS

Now out of the semiworks stages is Western Precipitation Corp's. new continuous gypsum calcining process that reportedly increases thermal efficiency to 78%—a sharp rise from the 30% efficiency of the conventional kettle process.

With it, high-compressive-strength products have been made from rock containing 78% $CaSO_4 \cdot H_2O$. This results from the ability to control rate and degree of calcination, residence time, temperature differential between heat source and gypsum rock, and draft conditions.

Other advantages claimed:

- Conventional preparation equipment is used.
- Continuous drying, grinding and ball-milling eliminate need for large surge bins.
- Normal installation cost.
- Rapid startup and shutdown plus interchangeability of product.

► **Two-Stage Process** — The new technique employs: (1) a conventional preparation system in which the rock is dried and ground to a fineness of 95% minus 100 mesh, and (2) the continuous calcination setup. Latter includes a 4-section calciner employing indirect heat supplied by a conventional forced-circulation system using a transfer medium such as aromatic oil, at approximately 550 F.

Ground rock is fed to the calciner by a constant-weight feeder and subjected to a preheat of 220 F. in the first section. Further dehydration occurs in sections 2 and 3 under isothermal conditions. Section 4 is used to yield the hemihydrate.

Dust is separated from the vapor stream by means of a small electrostatic precipitator and re-introduced to the calciner.

The calciner is comprised of a multitude of hollow vertical plates having a rectangular cross section housed in a common shell. Each section of the 2,000-lb./hr. pilot unit is made up of four plates 7 ft. long, spaced 2½ in. apart to form three ducts for containing the solids. Rock is propelled forward and sideways through each section by overlapping sets of narrow paddle arms. Shafts carrying the paddles are mounted above the vertical plates.

Quality of the hemihydrate produced is not dependent on rock quality as the calciner controls will automatically compensate temperaturewise for degree of inerts present. By establishing a final dump temperature and setting the agitator speed, hemihydrates can be tailored for specific use.—MDR, AVG

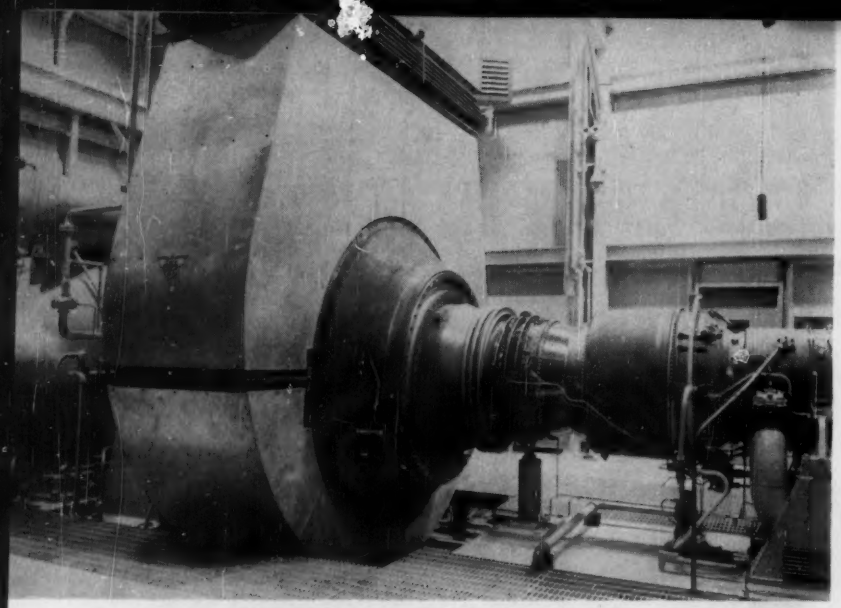
Operating and design data

Process

Production	2,000 lb./hr.
Feed grind	95% minus 100 mesh
Bulk density, feed	62 lb./cu. ft.
Inlet temperature	95 F.
Outlet temperature	340 F.
Heating medium	Aromatic oil

Design Specifications

Number of sections	4
Length of sections	7 ft.
Number of ducts	3
Total surface area	168 sq. ft.
Total width	16 in.
Total length	28½ ft.
Total height	27 in.
Number of paddles/shaft	3



Jet gas turbine, compressor, pump 600 million cu. ft./day of natural gas.

JET ENGINE IS GROUNDED TO DRIVE PIPELINE COMPRESSOR

Modified J-57 goes into 10,500-hp. turbine unit in bold move to supplant more conventional drives.

In an unprecedented first in natural gas transmission service, Columbia Gulf Transmission Co. has harnessed the 10,500 hp. of an aircraft jet engine to drive a compressor at a main line compression station at Clementsville, Ky.

A cooperative endeavor of Columbia Gulf, Cooper-Bessemer and Pratt & Whitney, the experimental installation represents a marriage of C-B's engine and compressor know-how with P&W's vast experience in jet engines. The offspring: a jet gas turbine that weighs 84% less than a conventional gas turbine, 95% less than a reciprocating engine.

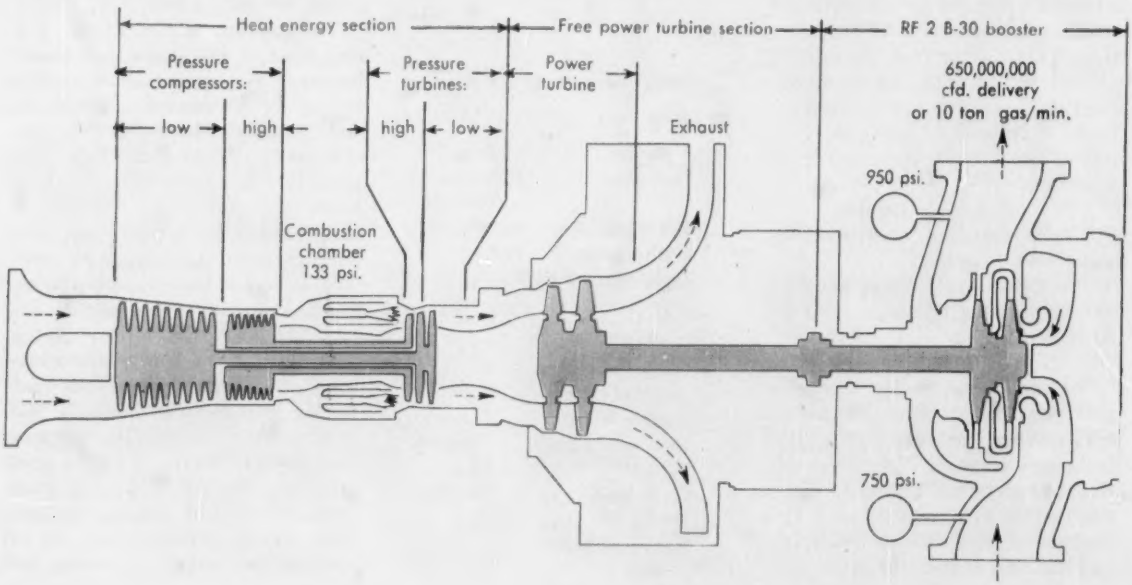
CGT lists many other advantages for a jet turbine compressor system:

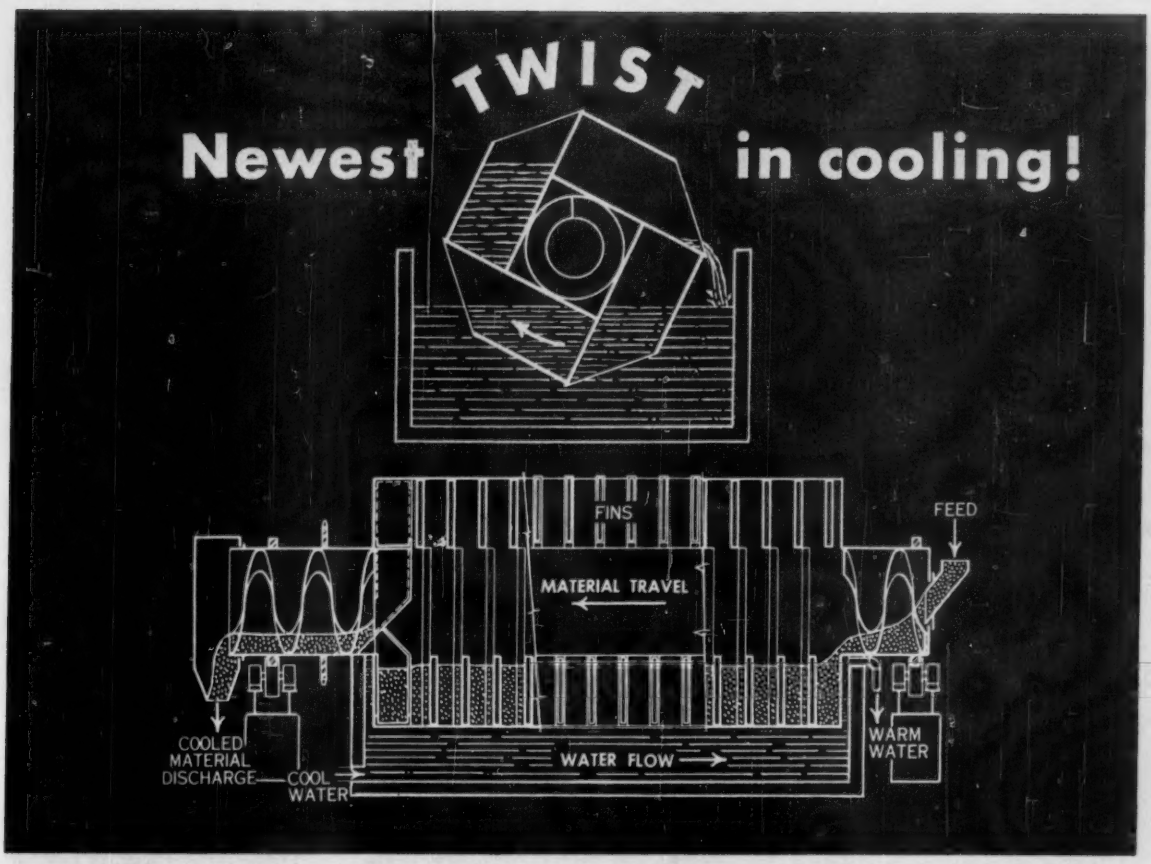
- Installation costs are almost 50% less than for regular gas turbine or reciprocating engine systems.
- Cooling water and lubricating oil requirements are practically eliminated.
- Vibration in turbine station is ended.
- Torque is more uniform and mechanical efficiency of turbine-compressor link is better (compared with reciprocating engine).

Disadvantage: Efficiency—Chief disadvantage of the jet turbine (in common with all contemporary gas turbines) is poor thermal efficiency. A supercharged reciprocating engine can achieve efficiencies as high as 41% while the jet gas turbine claims only 25%. Traditional open-cycle gas turbine is about 20% efficient; with a regenerator, it can match the jet engine.

CGT assays the higher fuel costs for the jet (compared with a reciprocating unit), judges that savings in installation, maintenance and other operating costs offset the fuel cost.

Another major advantage of the jet engine is the speed with which it can be removed for major repairs or routine overhauls. While a con-





HERE'S HOW IT WORKS! The Roto-Fin is a rotating drum with a series of flat, dual-purpose hollow fins or "cells" lapped to form an Archimedes spiral around the inside of the shell. As the cells are welded together, their surfaces form one continuous spiral. Yet individually, each cell is a separate heat exchanger with an opening on the outer periphery of the drum.

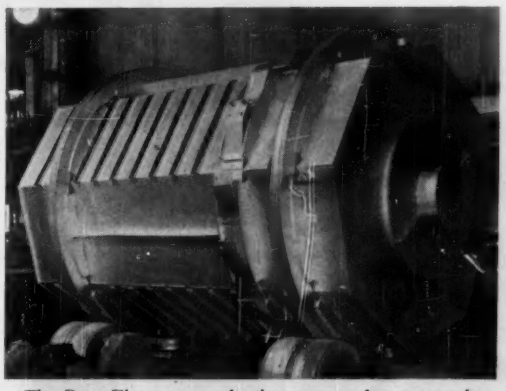
As the drum revolves partly submerged in water, the material to be cooled is conveyed down its spiral length from one turn in the spiral to the next. The openings of the individual cells continuously scoop up cold water and empty with each revolution of the drum to realize overall heat transfer coefficients as high as 20 b.t.u./hr./sq. ft. deg. F. on high temperature applications.

New Link-Belt ROTO-FIN Cooler has deep fin design for maximum cooling surface

Here's an efficient and low cost means of cooling a wide variety of materials. Water-cooled surfaces of rotating fins are in constant contact with product, assuring a rapid transfer of heat.

ROTO-FIN'S design is simple with minimum number of moving parts for continuous, trouble-free operation. No fans, collectors or elaborate controls are required. A unique self-cleaning feature prevents contamination when handling different products.

A laboratory ROTO-FIN is available for testing materials at your plant. Make arrangements by calling your nearest Link-Belt office today.



The Roto-Fin, new conduction-type cooler, rotates in tank of cool water. Deep hollow fins, with water circulating within them and material traveling through the drum between them provide maximum conduction cooling surface.

LINK-BELT

COOLERS • DRYERS • ROASTERS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses and District Sales Offices in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,585

ventional gas turbine system with regenerator might require weeks of shutdown for an overhaul, the jet section can be removed and a substitute installed in four hours.

Background—The new engine is a modified version of P&W's J-57 aircraft engines, over 19,000 of which propel military and commercial planes. The stationary version, adapted to run on natural gas, never reaches jet takeoff speeds, temperatures or stresses.

Linked to the turbine, it will operate at or below low-stress flight cruising speed. This deliberate derating is designed to give low running temperatures, prolonged service life—resulting in an 8,000-hr. running time between overhauls.

The engine-turbine combination, called the RT-248, works like this: large quantities of air are drawn into the engine, compressed and heated by the burning of natural gas. The heated gases give up their energy of expansion to drive both the engine compressor and the power turbine, then exhaust to atmosphere. The turbine shaft is connected directly to the centrifugal compressor for the pumping of atural gas through the pipeline.

Better than Aircraft — Officials of the three companies expect that jet engine performance in the RT-248 will surpass that achieved in aircraft applications. This is possible because it will not have to cope with the varying load and overload conditions that are considered normal performance for aircraft jet engines. Instead, in gas compression service, the engine will operate primarily under constant load conditions and should be free of the thermal shock loads experienced in aircraft service.—FCP

NEW ABSORBENTS CUT H_2S REMOVAL COST

Sodium salts of anthraquinone, which are the heart of new gas-sweetening process, wash out the sulfur, give it up to pay part of freight.

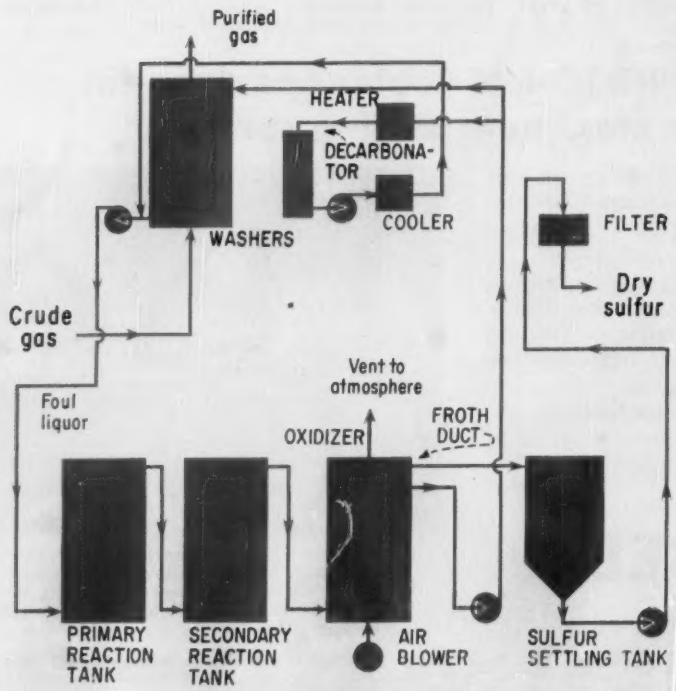
Using byproducts of anthraquinone manufacture as absorbents for H_2S, a new British gas-sweetening process reportedly cuts operating costs to less than ⅓ of the conventional iron-oxide purification systems (*Chementator*, Nov. 14, p. 103)

Other advantages of the new technique are that it:

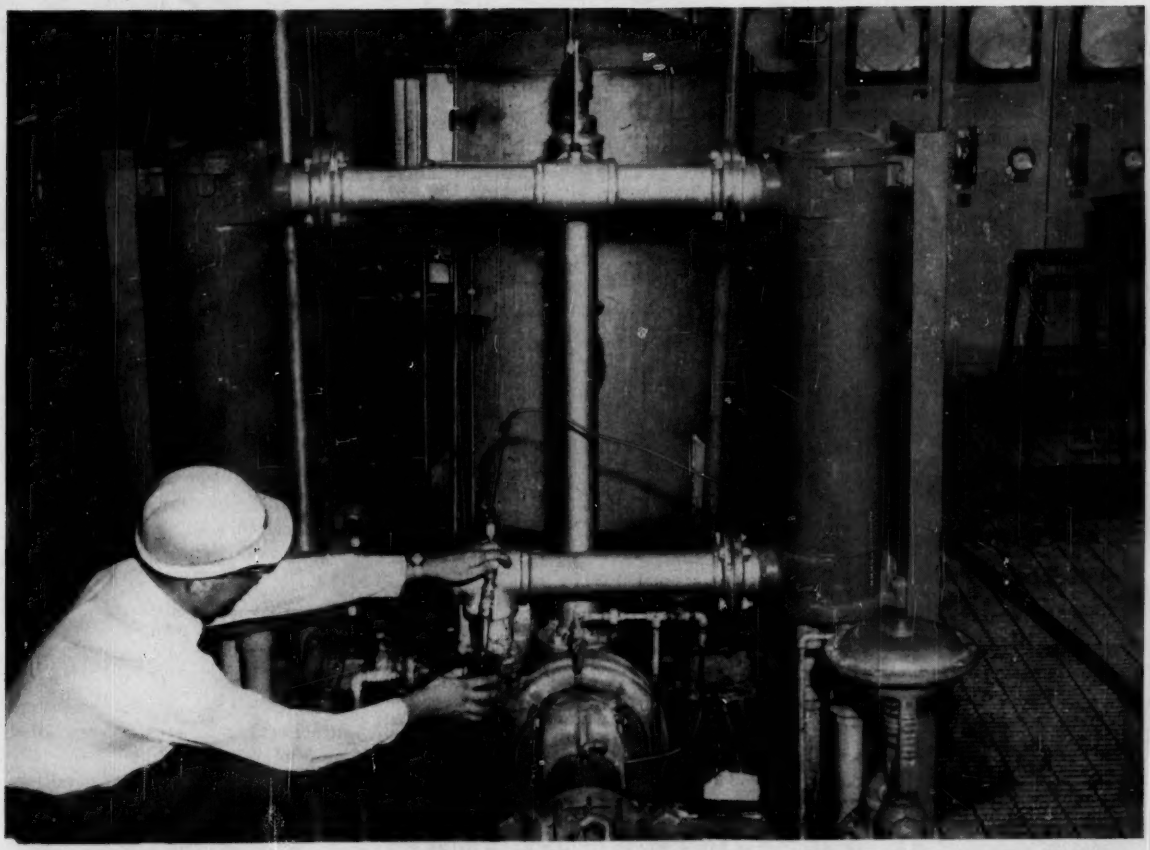
- Purifies gases easily to fractional ppm. of residual H_2S.
- Produces sulfur that is free from arsenic and iron oxide.
- Employs absorbents that are stable, eliminating need for frequent replacement. In addition, they are nontoxic and easily handled.
- Presents no unusual corrosion problems.

▶ **Other Applications** — Although presently used to remove sulfur from manufactured gases, numerous other applications are envisioned:

1. Removal of H_2S from waste gases at oil fields, resulting in recovery of marketable sulfur and elimination of odor.
2. Treatment of waste gases at oil refineries and tail gases sold to chemical and gas industries.
3. Cheaper purification of a wide range of liquids containing H_2S.
4. Removal of H_2S and carbon bisulfide from the air in the rayon and transparent-paper industries.
5. Recovery of pure sulfur in the



◀ **In processing cycle, H_2S is scrubbed from the gas in washer (left), then converted to free sulfur and removed by filter (right). Solution is regenerated in oxidizer, then recycled to washer.**



Shows high resistance to corrosive attack. Ni-o-nel alloy is used for tubing in double dilution heat exchanger of synthetic-detergent plants designed by Chemithon Corporation of Seattle, Washington. Ni-o-nel alloy was selected after extensive material testing as being best suited to handle 78% sulfuric acid at 115-120°F.

Protects product purity

High-nickel Ni-o-nel alloy resists attack by hot sulfuric acid solutions

Ni-o-nel* nickel-iron-chromium alloy resists corrosion in sulfuric acid solutions up to about **40% concentration by weight at boiling temperature,** up to **60% concentration at 176°F.** At room temperature, it has good resistance at *all* concentrations.

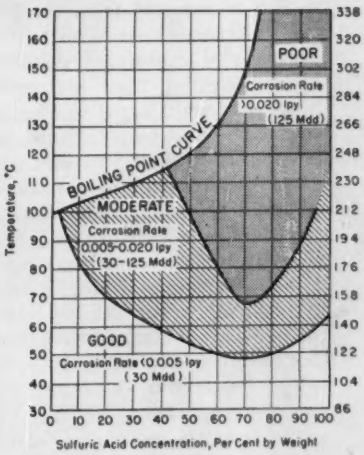
The corrosion resistance of Ni-o-nel alloy in sulfuric acid solutions is improved by the presence of oxidizing agents. Thus the alloy is outstanding for use with hot mixtures of sulfuric acid with nitric acid, cupric sulfate, or ferric sulfate.

Readily welded. The metal-arc welding of Ni-o-nel alloy follows the standard procedures used for Inconel* nickel-chromium alloy. And you simply exercise the same precautions about cleanliness of surface, use of annealed material, and removal of all slag before depositing successive beads in a multi-pass weld. Or you can use the tungsten-inert gas process equally well.

Get full story. In Ni-o-nel you have an important ally in any battle you wage against troublesome corrosive conditions. For details, see our bulletin, *Engineering Properties of Ni-o-nel.* This bulletin describes composition, physical and chemical properties, and includes detailed information on applications. Write today for copy of "Technical Bulletin T-37", for help in selecting materials to resist severely corrosive conditions.

*INCO trademark

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
Huntington 17, West Virginia



Iso-Corrosion Chart for Ni-o-nel alloy in sulfuric acid, based on laboratory data using pure acid.

NI-O-NEL®

purification of synthesis feed gas.

▶**Passed Plant Tests**—Developed by a team of North Western Gas Board technologists and researchers from The Clayton Aniline Co., Manchester, England, the new technique is called "Stretford" process. It proceeds in three steps: (1) Na_2CO_3 and $NaHCO_3$ present in the absorbent solution react with H_2S in the gas to produce NaHS; (2) anthraquinone disulfonic acid salts in the absorbent solution react with the NaHS to give free sulfur and hydroquinone; and (3) stage 2 is reversed in presence of air with production of water.

Process is presently operating at two NWGB plants:

1. A 24,000-cu. ft./day facility at Whitchurch where, for almost two years, semipurified horizontal retort gas with 30-40 grains H_2S/100 cu. ft. has been handled.

2. A 6-million-cu. ft./day plant at Linacre that has been on stream approximately six months sweetening water gas that contains 200 grains H_2S/100 cu. ft. This plant was designed for use with the Manchester process, and handled 3 million cu. ft. when so used.

In these plants, gas to be treated contacts the absorbent—a 0.5% solution of sodium salts of 2,6- and 2,7-anthraquinone disulfonic acids at pH 9.0—in a washer.

Solution is sprayed from nozzles in top of washer and, as it flows downward in a film over the boards, the H_2S is removed from the gas. Gas is discharged ready for use.

The liquid containing dissolved H_2S is removed from bottom of washer and transferred to reaction tanks. It is held here for sufficient time to permit the H_2S to react with the carbonyl group in the absorbent and produce free sulfur and hydroquinone. Mixture is then pumped to an oxidation tower through injectors which entrain sufficient air to convert the hydroquinone back to the original anthraquinone disulfonic acids.

The free sulfur is caught in a finely divided foam which is removed from the tower and fed to a rotary vacuum filter for recovery of the sulfur. Absorbent solution is returned to the washer.

▶**Economics of Operation**—Based on an 8-mo. performance of a 3-million-cu. ft./day plant, cost of gas purification ranged from 25.9-28.3.¢./therm (differences represent estimated cost of replacing the anthraquinone absorbent, whether at end of one or two years).

The above figures do not take into account the revenue from sale of recovered sulfur. When this income is included, the costs are reduced to 0.1-0.2¢./therm, depending on market price of sulfur. Incidentally, cost of sulfur removal by the previously used iron oxide box system was 0.3¢./therm.

From the standpoint of capital investment, the Stretford process also claims an advantage. It is estimated that a new plant designed for use of this process could be built for about 0.083¢./therm. This compares with a cost of 0.142¢./therm for an oxide box installation.—AVG

Mexico Adds Foreign Aid To Petrochemical Plans

Pascual Roldan, director general of Petroleos Mexicanos (Pemex), has announced plans to provide technical and financial aid to help develop petrochemical enterprises in Venezuela, Brazil, Argentina, Peru and Bolivia.

Mexican engineers have already gone to La Paz to help Bolivians install a fertilizer plant. They are also studying a government oil development in southeastern Bolivia. An estimated 35,000 bbl./day of oil will be produced by 1963. Under tentative plans, Mexico would get shipments of Bolivia's light crude oil to complement its own heavy crude, in return for credit and technical assistance.

Reviewing current Mexican progress in oil and petrochemicals, Roldan listed the following:

• By spring, a $24-million, 500-mi. gas line from a Pemex installation in the south to Mexico City will be completed.

• With $20 million capital, some of Cuban origin, Pemex will build five fertilizer plants.

• Big sulfur deposits around Minatitlan, south of Veracruz, are slated for development.

• Pemex will produce all basic plastics needed in Mexico in 1961.

Also announced: that Veracruz will be the site of the most important complex of the petrochemical industry; that preliminary study has been completed for cutting a canal across southern Mexico.

Controlled Squeezing Molds Polytetrafluoroethylene

A superior grade of sintered polytetrafluoroethylene (better known under the trade name of Teflon) results from a molding process patented by Continental-Diamond Fibre Corp., Newark, Del. New process (U. S. 2,939,178) allows preformed billets to expand to a controlled final pressure during sintering, compresses them to final size during cooling.

The method avoids shortcomings inherent in two other methods: sintering without pressure produces a porous article containing incipient cracks; sintering without expansion or with uncontrolled overflow results in a hard, leathery product. Extra added advantages: new process works equally well with virgin material or reclaimed material that has previously been sintered.

In operation, powdered feed is preformed at 2,000 psi. in the form of a hollow cylinder, which is placed in a mold and sintered. During sintering, material expands from 15 to 35% along the axis of the cylinder, under final pressures ranging from 400 to 1,800 psi. The sintered article is then cooled under about 2,000-psi. compression, which reduces it to a final shape just a little smaller than the original preform.

Billets formed in this way may be skived (cut into sheets) to give a uniform sheet that has superior dielectric properties compared with a product produced by the conventional method of heating without pressure, viz., a 3-mil tape skived from a billet made in a confined mold has only half the number of pinholes as a tape skived from a conventional billet.

NEW 800 SERIES

WASTE TREATMENT

FROM DIAGNOSIS TO DISPOSAL

INDUSTRIAL, through its research and development groups, now offers the most complete waste treatment service available in the world today. The 800 Series inorganic waste treatment program includes:

- Preliminary survey service
- Pre-designed package plants
- Compact custom designed plants
- Installation service
- Continuing monitor service.

Systems for *liquid/solid separation*, *gravity* or *pressure separation*, by manual, remote or full automatic control or programming, are available for handling these solutions:

ACID • ALKALI • CYANIDE • CHROME • OIL

Write Dept. 800 for further details.

INDUSTRIAL **FILTER & PUMP MFG. CO.**
5918 Ogden Avenue • Cicero, Illinois

Pressure Filters • Ion Exchangers • Corrosion Test Cabinets
Pumps • Water & Waste-Treating Equipment

C-360

CPI News Briefs

- Processes
- Plants
- Offices
- Companies
- International

Plants

Tidewater Oil Co. will construct a 20,000-bbl./day Isocracking unit at its Avon Refinery near San Francisco. Developed and licensed by California Research Corp., subsidiary of Standard Oil Co. of California, Isocracking is a process that produces high-octane gasoline from gas oils. The new unit is expected to cost over $20 million, with construction scheduled to start early in 1961.

Tidewater is the second company that has recently announced plans to use California Research's process. The Standard Oil Co. (Ohio) will also install an Isocracker, at its refinery at Toledo, Ohio (*Chem. Eng.*, Nov. 28, 1960, p. 166).

Pacific Gas & Electric Co., San Francisco, has received a permit from the AEC for installation of a nuclear reactor at its Humboldt Bay power plant near Eureka, Calif. Facility will be a direct-cycle boiling water reactor with natural internal circulation; its gross output will be 50,000-60,000 kw. Reactor will supplement two conventional steam-electric generating units, which now comprise the Humboldt Bay plant and have a combined normal capacity of 100,000 kw.

Western Petrochemical Corp. has completed a $1.3-million expansion and modernization program at its Chanute, Kan., refinery, which is operated by the firm's Warwick Wax Div. Included in the project are new propane deasphalting facilities, additional vacuum distillation units and a Thermofor Continuous Percolation bleaching unit. Latter facility, which provides continuous adsorption bleaching of wax products, is the first of its kind in the world to be used in wax manufacture. Western claims that its new equipment will permit a higher quality level for high-melting microcrystalline waxes.

Arkansas Grain Corp. has recently opened a $2.1-million soybean processing plant at Stuttgart, Ark. It produces useful products from all constituents of the raw-material soybeans. Output includes 50 and 44%-protein meal, soybean mill feed, soybean meal pellets, crude soybean oil and crude lecithin.

American Potash & Chemical Corp. has recently completed two major construction projects at its sodium chlorate plants. Production capacity at the firm's Aberdeen, Miss., facility was increased by 50% through completion of an expansion project that was started last spring. And, a modernization program involving replacement of a sodium-chlorate recovery system has been completed at American Potash's plant in Henderson, Nev. These projects are said to make the company the world's largest producer of sodium chlorate.

Kaiser Aluminum & Chemical Corp. will build a $700,000 plant at its Baton Rouge, La., alumina works, to produce active alumina of uniform spherical shape. The new facility will provide a fivefold increase in Kaiser's production capacity for active alumina, which finds principal use as a desiccant for liquids and gases and as a catalyst or catalyst carrier. The project at Baton Rouge is due to be completed in the second quarter of 1961.

Hooker Chemical Corp.'s Phosphorus Div. has put a new commercial-scale unit on stream to produce tetrapotassium pyrophosphate at the division's Jeffersonville, Ind., plant. Commonly designated TKPP, the product is used in manufacture of heavy-duty liquid detergents for household laundries. Basic raw materials for its production are phosphoric acid and caustic potash, both of which are made by Hooker.

National Starch & Chemical Corp. has started up a polyvinylidene chloride resin plant at the firm's works in Meredosia, Ill. Capacity of the new unit is 14 million lb./yr., bringing the total annual productive capacity at Meredosia to over 80 million lb. of various polymer emulsions and latices.

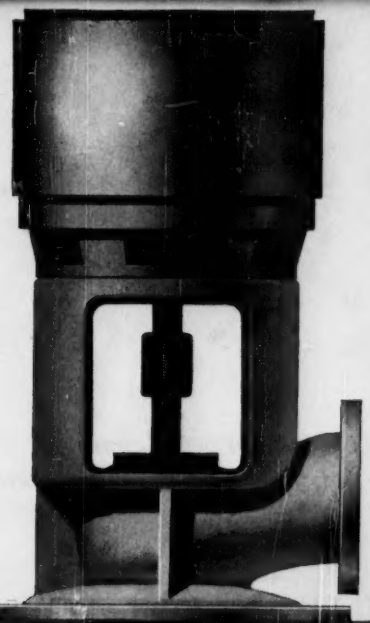
Humble Oil & Refining Co.'s Humble Div. has announced expansion plans for the paraxylene plant at its refinery in Baytown, Tex. Capacity will be increased from 65 million to 105 million lb./yr. by the first quarter of 1962. Engineering work for the program is already under way, and construction is expected to start early in 1961. The project will also provide a substantial increase in orthoxylene production.

Texas Gulf Sulphur Co. is beginning construction of a $25-million potash mining and processing plant in southeastern Utah, following a decision to purchase extensive potash reserves near Moab, Utah. Facility will be able to produce well over a million tons per year of muriate of potash, and the firm hopes to start marketing by around the end of 1962.

Humble Oil & Refining Co.'s Esso Standard Div. will expand its underground storage facilities for LPG at Sorrento, La. Located about 35 mi. south of Baton Rouge, La., these facilities consist of cavities in salt domes and are used for off-season storage of light hydrocarbons produced at the firm's Baton Rouge Refinery. The expansion will amount to 350,000 bbl. of capacity, will cost about $380,000. It is to be completed in about seven months.

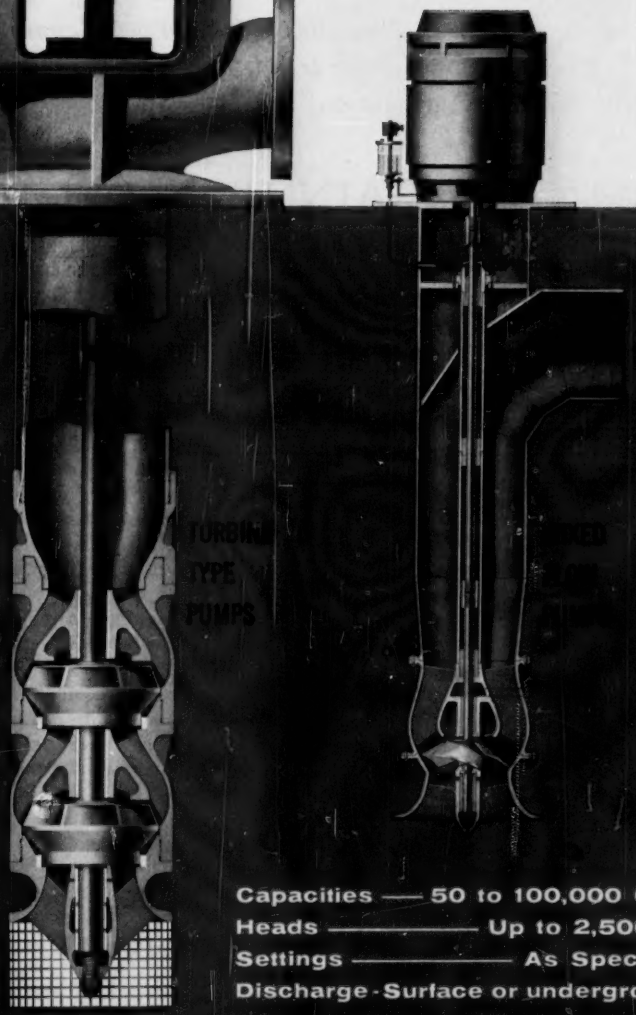
Carolinas Virginia Nuclear Power Associates, Inc., recently conducted groundbreaking ceremonies for its forthcoming atomic power plant at Parr, S. C. Rep-

CPI News Briefs (continued on page 118)



Layne

SHORT COUPLED SERVICE PUMPS for any job



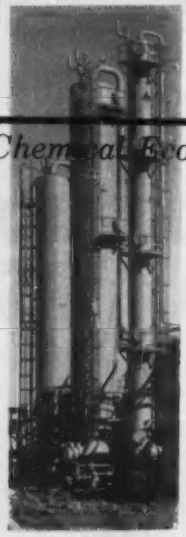
Capacities — 50 to 100,000 GPM
Heads — Up to 2,500 Ft.
Settings — As Specified
Discharge - Surface or underground

Top performance, high efficiency and less maintenance are factors which influence the selection of a short coupled pump. Layne Vertical Service Pumps fulfill these requirements and offer the advantages of lower installation and operation costs, low submergence requirements, simple alignment, no priming and less floor space demands. For any short coupled pumping job . . . specify Layne.

Write For Free Bulletins:
LAYNE TURBINE TYPE SERVICE PUMPS—NO. 300
LAYNE PROPELLER AND MIXED FLOW PUMPS—NO. 350

World's Largest Layne Water Developers

LAYNE & BOWLER, INC., MEMPHIS
General Offices and Factory, Memphis 8, Tenn.
LAYNE ASSOCIATE COMPANIES THROUGHOUT THE WORLD
SALES REPRESENTATIVES IN MAJOR CITIES



Chemical Economics

Petrochemicals 5

Lineup for the Series

1. Petrochemicals Map Their Mature Years, May 30, p. 54
2. Chemicals From Methane, June 27, p. 74
3. Ethylene Copes With Growing Competition, Aug. 22, p. 66
4. Propylene Sires Industry's New Hopefuls, Sept. 5, p. 60
5. **Oil-Based Aromatics Gain First Place**

Naphthalene, last big holdout in aromatics' shift to a petroleum base, is catching up fast. Another major trend: new processes for making both primary and derivative aromatics.

OIL-BASED AROMATICS GAIN FIRST PLACE

RICHARD F. MESSING AND
JAMES W. BRADLEY,
*Arthur D. Little, Inc.**

During the past few months, petroleum companies have been entering the naphthalene field at a feverish rate. These entries foretell the end of dependancy of coal-tar sources for naphthalene and, for that matter, for all of the large-volume aromatic chemicals. For most aromatic chemicals other than naphthalene, production from petroleum already exceeds that derived from coal-tar sources. And the trend is expected to continue in this direction.

Development of the aromatic segment of the petrochemical industry has been closely tied to the relationship between available supplies from the coking industry and demands by chemical processors. Variability of supply, resulting from fluctuating levels of steel production, has impelled users to seek new sources that can provide a more constant supply and stable pricing. The future of coke by-products may be somewhat influenced by adoption of direct-reduction processes for iron ore, which avoid use of coke entirely.

In addition to aromatics in quantity from petroleum for the first time, new trends in the field concern methods of manufacture of both the primary and derivative aromatics.

Widespread installation of plants for hydrodealkylation of alkylated aromatics provides an outstanding example.

This process forms the basis for the naphthalene recovery units that have been planned by the industry, and will also be the basis for new facilities for conversion of toluene to benzene. Toluene is coproduced with petroleum benzene in a somewhat inflexible ratio depending upon the feedstock, and its disposal continues to be a major problem for refiners.

Dow Chemical is approaching the same problem through installation of a facility for conversion of toluene to phenol; all other processes utilize benzene as the principal raw material. This should place Dow in a position to capitalize on the relatively wider availability and lower price of toluene.

Another significant process announcement: Petro-Tex will utilize a butylene raw material instead of benzene for manufacture of maleic anhydride. Benzene has been the traditional raw-material source for the maleic anhydride industry.

Petrochemicals-5

NEW PROCESSES ALTER BENZENE OUTLOOK

Extraction of light aromatics from catalytic reforming streams has been the first step for many refiners starting up in petrochemicals. Unlike the aliphatics, the aromatics are not available from alternate sources open to exploitation by the chemical companies, so the petroleum companies have a unique opportunity for upgrading of reformate streams. This opportunity has become even more attractive because of the general relaxation in Detroit's demands for higher and higher octanes, freeing surplus octane capacity of many refiners for alternate uses.

Petroleum has already become by far the largest source for toluene and xylene, and has now grown significantly as a base for benzene. Starting from petroleum benzene's present capacity of about 305 million gal., about 194 million is either under construction or planned, representing about a 64% increase in capacity. If we take 60% of the total steel industry capacity as a realistic level of future recovery, this means that the total benzene available will be approximately 620 million gal. Much of this output will be available to displace imported benzene and possibly some

* For authors' biographies, see Chem. Eng., May 30, 1960, p. 54.

Only 14/10,000¢ of QO® Furfural is Required in Refining a Quart of Lube Oil... Investigate What QO Furfural Can Do For You as a Low Cost Selective Solvent . . .

in addition to economical separation of saturates from unsaturates in the refining of lube oil, furfural's characteristic preferential solubility is used in processing gas oils, cycle stocks, wood rosin, glycerides, and butadiene.

There are many other possibilities for separating mixtures by using QO furfural. If you have a separation problem, write for information indicating the nature of the material to be extracted. For physical data, ask for Bulletin 203-A.

The Quaker Oats Company

CHEMICALS DIVISION

335P The Merchandise Mart,
Chicago 54, Illinois

Room 535P, 120 Wall St.,
New York 5, N. Y.

Room 435P, 49 S.E. Clay Street
Portland 14, Oregon

In the United Kingdom:
Imperial Chemical Industries, Ltd., London, England

In Europe:
Quaker Oats-Graanproducten N. V., Rotterdam, The Netherlands;
Quaker Oats (France) S. A., 3, Rue Pillet-Will, Paris IX, France;
A/S "Ota", Copenhagen, S. Denmark

In Australia:
Swift & Company, Ltd., Sydney

In Japan:
F. Kanematsu & Company, Ltd., Tokyo

of the coal-tar sources, but the amount of total capacity is still impressive when contrasted with the estimated 1959 consumption of 404 million gal.

Imports of benzene to the U. S. were an important factor in the supply picture in 1959. With the installation of additional capacity in the U. S., and with growing demands for benzene in the countries of origin, there will probably be a continuing downtrend in supply from external sources. The Iron Curtain countries have been a sig-

Benzene Sources (million gallons)

	1957	1958	1959
Tar distillers	36	27	18
Coke-oven operators	179	118	120
Petroleum operators	116	142	209
Total	331	287	347
Imports	55	45	57
Grand total	**386**	**332**	**404**

Toluene Sources (million gallons)

	1957	1958	1959
Tar distillers	5	4	4
Coke-oven operators	38	28	27
Petroleum operators	155	207	251
Total	198	239	282
Imports	1	1	1
Grand total	**199**	**240**	**283**

Xylene Sources (million gallons)

	1957	1958	1959
Tar distillers	1	1	..
Coke-oven operators	11	8	8
Petroleum operators	115	191	233
Total	127	200	241
Imports	...	...	2
Grand total	**127**	**200**	**243**

* Source: U. S. Tariff Commission.

BTX Capacity (million gallons/year)

Producer & Location	Benzene	Toluene	Xylene
From petroleum			
Amoco, Texas City, Tex.	15	10	5
Ashland Oil, Buffalo, N. Y.[1]	13 (10*)	8	....
Catlettsburg, Ky.	15 (11*)	..	..
Atlas Processing, Shreveport, La.	9	..	..
Chemoil, New Orleans, La.	3 (3*)	..	..
Cities Service, Lake Charles, La.[2]			16.5 (16.5*)
Continental Oil, Lake Charles, La.	5.5	..	..
Ponca City, Okla.	6	..	..
Cosden, Big Springs, Tex.[2]	6	7	11
Delhi-Taylor, Corpus Christi, Tex.[2]	18.5	14	21.5 (9.5*)
Great Southern, Corpus Christi, Tex.	9	12	..
Gulf Oil, Port Arthur, Tex	32	5	..
Philadelphia, Pa.	12 (12*)	..	..
Humble Oil, Baton Rouge, La.	21 (9*)	9	..
Baytown, Tex.[2]	30	50	79 (4*)
Leonard Refineries, Mt. Pleasant, Mich.	6	3	..
Mobil Chemical, Beaumont, Tex.	30 (30*)	..	..
Phillips Petroleum Co. Sweeney, Tex.	22 (22)	..	..
Plymouth Oil, Texas City, Tex.[1]	15 (15*)	..	..
Pure Oil, Smiths Bluff, Ark.	8	..	..
Toledo, Ohio		9	17
Richfield Oil, Wilmington, Calif.	18	18	..
Shell Oil, Houston, Tex.	17	30	..
Wilmington, Calif.	9	10	10
Wood River, Ill.		13	17
Signal Oil & Gas, Houston, Tex.[1]	21 (10.5*)	..	..
Sinclair Houston, Tex.[2]		20	55 (10*)
Marcus Hook, Pa.[2]		6	15
Standard Oil (Calif) El Segundo, Calif.[2]	25	25	25
Richmond, Calif.[2]	6	..	23.5 (19.5*)
Standard Oil (Ind.), Whiting, Ind.	15	25	10
Sun Oil, Marcus Hook, Pa.	30 (12*)	25	15
Sunray, Tulsa, Okla.[1]	18 (9*)	..	..
Suntide, Corpus Christi, Tex.[1,2]	18 (12*)	13	14.5
South Hampton Co., Silsbee, Tex.[1]	5	..	..
Texas Oil, Port Arthur, Tex.	30 (30*)	..	..
Tennessee Oil Refining, Chalmette, La.	8 (8*)	..	..
Vickers Petroleum, Potwin, Kan.	2	5	7
Total	498 (193.5*)	317	342 (59.5*)
From coal			
Bethlehem Steel, U. S. Steel, Allied Chemical, American Cyanamid and others	207	42	12
Grand Total	705 (193.5*)	359	354 (59.5*)

* That portion of the listed capacity that is under construction or planned.
[1] The benezene unit under construction or planned is a Hydeal unit.
[2] Company separates xylenes.

nificant source, with exports of about 45 million gal. to the U. S. last year, but again the long-term outlook for this supply is far from certain.

Probably the most important change in the benzene supply picture will derive from installation of units for conversion of toluene to benzene by the Hydeal process. Total capacity for Hydeal benzene now being installed or operating amounts to 61 million gal., which in turn will absorb 72 million gal. of toluene*. Availability of this method will give the industry greater flexibility in terms of balancing relative demand for benzene and toluene, particularly in view of the anticipated increase in growth for benzene derivatives. Furthermore, it may ultimately result in some adjustment in relative pricing of the two materials, although it seems obvious that toluene will necessarily maintain a lower price schedule in order to justify its conversion to benzene.

Many of the benzene producers will tend to upgrade their output and thereby place themselves more in competition with the chemical producers; e.g., Texaco, not a producer of phenol itself, recently completed a unit to supply cumene to Allied, a phenol producer that apparently has abandoned production of cumene. More and more chemical producers may find the return on investment in some of the primary petrochemical facilities to be sufficiently unattractive to force them to concentrate on further upgrading.

Usage of benzene in styrene, 185 million gal. in 1959, should continue to benefit from growth in volume of SBR rubber and also development of the newer outlets for polystyrene resins including foams, packaging and postformed sheets. The outlook in these categories has already been discussed in the portion of this series dealing with ethylene derivatives. While styrene is now based primarily on benzene obtained from coal tar or petroleum sources, most of the new units will utilize ethyl benzene from reformate streams, instead of the alkylate obtained by combining benzene and ethylene.

Synthetic phenol, which consumed 86 million gal. of benzene in 1959, represents an interesting example of a field where four processes used by different companies compete economically. Now, a fifth is about to be adopted. The latter will involve conversion of toluene to phenol by an oxidation process being installed by Dow. Economics of each of the routes for phenol manufacture depends to a substantial degree upon the availability of markets for byproducts generated in the process, including such materials as diphenyl oxide, hydrochloric acid, sodium sulfate, acetone and dichlorobenzene.

Local market conditions, plant size and process know-how may also influence selection among the available processes, although it is interesting to note that each has been chosen as a route for expansion by a major producer within the last few years. Dow's new method is the only one that avoids the use of benzene as the ultimate starting material and directly reflects the relative supply position of toluene and benzene. As already noted, the price of toluene, which is about 9¢/gal. under that for benzene, makes it an attractive material to consider for use in a chemical synthesis, particularly with the long-term outlook favoring continued excess supply of toluene from catalytic reforming units.

Nearly one-half of phenol's 692-million-lb. total consumption in 1959 was for phenolic resins, which took 320 million lb. Several other uses will probably show a faster growth, however, particularly bisphenol-A used as a raw material for epoxy resins, and caprolactam used in making nylon-6 for both plastics and fiber markets. Bisphenol A took 44 million lb., caprolactam took 41 million. Other uses: 85 million lb. to alkyl and chlorinated phenols; 20 million to selective solvents; 40 million exported; 142 million miscellaneous.

Caprolactam has, in fact, emerged

Synthetic Phenol Capacity (million pounds/year, est.)

Producer	Location	Capacity	Process
Allied Chemical	Frankford, Pa.	75 (30*)	Cumene
Dow Chemical	Midland, Mich.	220	Chlorination
	Kalma, Wash.	36 (36*)	Toluene Oxidation
Hercules Powder	Gibbstown, N. J.	30	Cumene
Hooker Chemical	N. Tonawanda, N. Y.	85	Raschig
	S. Shore, Ky.	?	Modified Raschig
Monsanto Chemical	Monsanto, Ill.	130 (10*)	Sulfonation
	Avon, Calif.	30	Sulfonation
	Texas City	50–75 (50–75*)	Cumene
Reichhold Chemical	Tuscaloosa, Ala.	90 (20*)	Sulfonation
	Tacoma, Wash.	30 (30*)	Sulfonation
Shell Chemical	Houston, Tex.	50	Cumene
Standard Oil (Calif.)	Richmond, Calif.	50	Cumene
Union Carbide	Marietta, Ohio	105 (20*)	Raschig
	Total	981+(196+*)	
Byproduct (Coal-Tar & Petroleum) Koppers, Pitt-Consol., Reilly Tar & Chemical, Allied Chemical, & others		44	
	Grand total	1025+(196+*)	

* That portion of the listed capacity that is under construction or planned.

Phenol Sources

Million pounds, est., 1959	
Benzene	514
Cumene	138
Natural byproducts	40
Total	692

* Unconfirmed at this writing: reports that Dow will build the country's largest Hydeal unit, 30 million gal./yr. at Freeport, Tex.; another 30-million-gal. plant, at Port Arthur, Tex., has just been announced by Texaco.

as one of the significant phenol outlets within the past few years. A process for caprolactam manufacture that apparently will not be based on use of phenol is now being installed, so that there is no assurance that phenol will continue to find a major market outlet in the manufacture of this product. Considerable expansion in phenol use will obviously be required to absorb the capacity now in place and under construction. The new plants represent an addition of 21% to the existing plant capacity.

The next major outlet for benzene, dodecyl benzene—36 million gal. in 1959, shows signs of becoming stabilized as the penetration of synthetic detergents into the cleansers market becomes more complete. The alkyl benzene compounds are subject to competition from other chemical types, particularly the ethoxylated tall oil acid type, but the alkyl benzene sulfonate derivatives continue to predominate.

The use of benzene as an intermediate to synthetic fibers—35 million gal. in 1959—is also subject to competition from other alternate routes to the same end products. Essentially, all of this usage occurs within the area of nylon intermediates, where the benzene is converted to adipic acid and hexamethylenediamine through either cyclohexane or cyclohexanol. It is interesting to note that one plant producing nylon intermediates from furfural was recently closed, and that the second major producer bases its synthesis entirely upon the cyclohexane method. Benzene should, therefore, hold its position as a route to nylon.

The other significant outlet where process changes are bringing about a shift in benzene demand is in maleic anhydride manufacture (10 million gal. in 1959). The introduction of a process based directly upon butylene oxidation may foretell a more-limited future for benzene use in this outlet. Nevertheless, two companies now entering the maleic anhydride field will use benzene as a feedstock, as will the five other plants being installed by present producers, so that it might be expected to share in the growth of this derivative.

Aniline manufacture took 16 million gal. of benzene in 1959; DDT took 16 million; exports 7 million; other, 13 million.

Petrochemicals-5

TOLUENE TO BOOST BENZENE SUPPLY

If one takes 60% of maximum coking capacity as a reasonable level, the availability of toluene from both petroleum and coal tar sources amounts to about 340 million gals. The end-use distribution reflects the relatively limited uses for toluene in solvent (28 million gal. in 1959), chemical (34 million gal.), explosive and misc. (15 million gal.), export markets (31 million gal.). About two-thirds of the output or 184 million gal., is returned to gasoline as a high-octane blending stock. Value for fuel use is considerably less than that for solvent- and chemical-grade toluene, particularly since most refiners have a satisfactory or even surplus octane position. Government requirements exert some influence in the toluene market, particularly for aviation gasoline and to some extent for explosives and propellants based on TNT.

In the solvents market, paint and related products represent the principal use for toluene, particularly where a high solvency material is required. About 2 million gal./yr. of toluene is consumed in the rubber industry, where it finds application as a solvent for rubber cement and other applications. It is also used in thinning of vinyl organosols and in dissolving inks.

The chemical markets include: conversion to benzyl chloride, benzoyl chloride, benzoic acid and other derivatives. The use of benzoic acid in placticizers has been developing quite satisfactorily, and it maintains an important position in the food industry as a preservative. A major outlet for benzoyl chloride is in making peroxide, which finds its major use as a polymerization catalyst. Flavor and perfume ingredients are other uses for chemicals in the benzoyl chloride series.

Toluene sulfonates continue to find an important outlet in the surfactants field, with production in 1958 reported at 9 million lb. In liquid detergents, the sulfonate serves as a solubilizing agent, while in powdered detergents, it is used as a conditioning agent to assist in maintaining free flow. Estimated consumption of toluene by the detergent industry is from 3 to 4 million gal./yr.

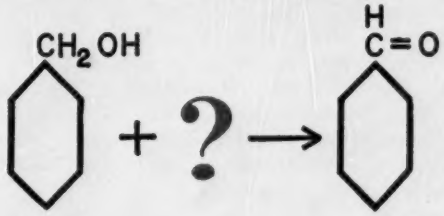
Probably the most significant new market for toluene is in the manufacture of tolyene diisocyante (TDI). TDI is regarded as the standard isocyanate component going into the manufacture of urethane products. Polyurethanes have unusually favorable characteristics for application in both rigid and flexible foam materials, as well as offering a potential for other fields including adhesives and surface coatings. Rigid foams have found application in structural sandwich materials and in insulation for special construction. A major opportunity may be offered such foams in the manufacture of refrigerators for household and industrial use. Flexible foams compete strongly with both natural and synthetic latex rubber foam. The price advantage in favor of the urethane product becomes especially significant when considered on a volume basis. Dow Chemical is consuming toluene for its vinyl toluene operations, but consumption is limited.

The fact that toluene has a smaller chemical market than benzene, has been one of the problems of the industry, which has been reflected in the price for toluene compared with benzene. In 1959, for example, the U. S. Tariff Commission reported that the average price for all benzene sold during that year was about 29¢/gal. vs. 19¢/gal. for toluene. The efforts of companies to either utilize toluene in place of benzene, or convert toluene to benzene, have been noted above.

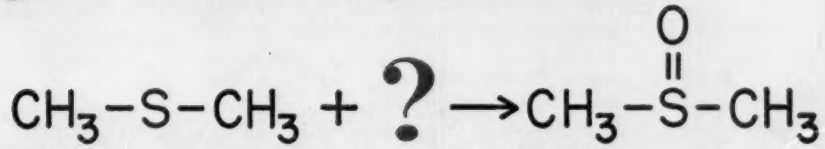
How would you conduct these difficult oxidation reactions?

PARTIAL OXIDATION:

Aromatic alcohol to aromatic aldehyde

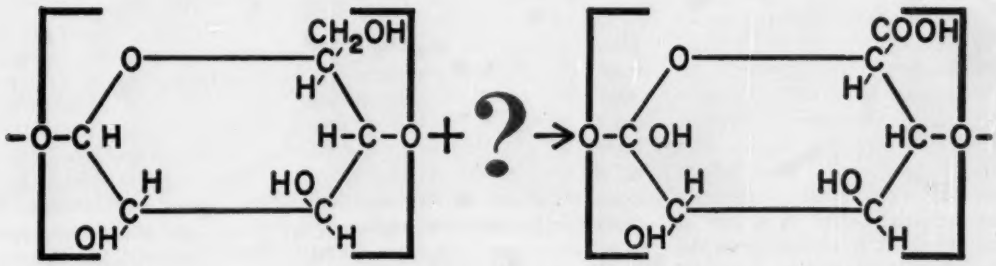


Organic sulfide to organic sulfoxide



SELECTIVE OXIDATION:

Starch or cellulose--alcohol groups only--to carboxyl groups



Allied Chemical Nitrogen Tetroxide, an abundant source of oxygen, may be the answer to *your* oxidation problems; it carries approximately 70% oxygen. Under mild conditions, half of this oxygen can be utilized; under more vigorous conditions, the total amount is available.

Nitrogen Tetroxide is a truly low cost oxidizer for reactions typical of those indicated above. It can be used in solutions at very low temperatures, such as NO in N_2O_4; in concentrated liquid form from −11° to 21° C.; in acids such as sulfuric and nitric; and as a gas in the form of NO_2 at elevated temperatures.

With a minimum of N_2O_4 content of 99.5% and less than 0.1% moisture, Allied Chemical Nitrogen Tetroxide is supplied in tank cars, one-ton, 150- and 125-lb. cylinders.

For application in your operation, write Allied Chemical.

For specifications and local offices, see our insert in Chemical Materials Catalog, pages 475-482 and in Chemical Week Buyer's Guide, pages 37-44.

BASIC TO AMERICA'S PROGRESS

Allied Chemical

NITROGEN DIVISION
Dept. NT15-5-3, 40 Rector St., New York 6, N. Y.

2819

Petrochemicals-5

FUEL STILL DOMINATES XYLENE MARKETS

Xylenes are obtained together with benzene and toluene by extraction from catalytic reforming streams. Fuel markets, about 106 million gal. in 1959, again predominate for xylene, although solvents, with about 64 million gal. in '59, take about one-quarter of the total 242.5-million-gal. output. The solvents are comparable to those for toluene's although with heavier emphasis on use in alkyd resins, where xylene serves as a standard solvent medium.

For its major chemical markets, xylene appears in the form of the separated ortho-, meta-, para-isomers. Estimated demand in 1959 for each isomer in manufacture of derivatives: ortho-xylene, 7 million gal.; meta-xylene, 4 million; para-xylene, 18 million. A greater quantity of some isomers may be separated but ultimately are returned to gasoline or solvent outlets. An estimate of the extent of this imbalance can be based on the following: natural isomer content of xylenes from either petroleum or coal distillation involves about twice as much of the meta-isomer as of the ortho- and para-, the latter two being present in about equal quantities. Consumption of meta-, on the other hand, is only 14% of the total estimated isomer consumption.

Ortho-xylene finds its major market in the production of phthalic anhydride, where it competes as a raw material with naphthalene. While only one phthalic anhydride plant is based solely upon use of ortho-xylene, it is evident from the reported 1959 production figure of 61 million lb. that a number of others also employ ortho-xylene as an alternate or supplementary feedstock in their phthalic anhydride operations. This substitution has been more necessary during the past year because of the inadequacy of naphthalene supply. A new process now being introduced abroad for conversion of ortho-xylene to phthalic anhydride may offer a more economic route to this synthesis, and should stimulate further interest on the part of domestic companies.

Meta-xylene is used by Standard Oil of California in its large operation for the manufacture of isophthalic acid, and it also is a component of the charge stock for the Amoco Chemicals plant at Joliet, Ill. Isophthalic markets have been effectively promoted in competition with phthalic anhydride, particularly in reinforced plastics and in plasticizers.

Para-xylene goes primarily into terephthalic acid, which is usually sold in the form of its dimethyl ester (DMT). Production of para-xylene in 1959 was reported as 160 million lb., although a portion of this is believed to have been shipped abroad rather than used domestically. Du Pont can make 80 million lb./yr. of DMT at Gibbstown, N. J., via the nitric acid oxidation process and 60 million lb. at Old Hickory, Tenn., by air oxidation, Hercules can make 12 million lb. at Burlington, N. J., and has an additional 24-million-lb. capacity under construction. Amoco can make 60 million lb. of DMT and other phthalic acids at Joliet, Ill., by liquid-phase air oxidation.

The DMT finds its major market in manufacture of polyesters that go into the synthetic fiber industry and into transparent films. Du Pont continues to be the largest factor in polyester fibers with Dacron, but competition is now coming from Tennessee Eastman and the Beaunit-Goodyear combine. Fiber Industries, a joint venture of Imperial Chemical and Celanese, also plans a major venture for polyester fiber production in North Carolina. In 1959, 61 million lb. of DMT went into polyester fiber staple, 26 million lb. into filament.

Du Pont is also the major factor in production of polyester films under its trade name Mylar, but Goodyear, Tennessee Eastman, and Minnesota Mining are also operating facilities for this type of product. Markets for the film include the electrical industry, laminated products and metallized films used in decorative surfaces. In 1959, 15 million lb. of DMT went into polyester films. Exports of 20 million lb. brought total consumption to 122 million lb.

There has been some interest in processes for rearrangement of phthalic anhydride and/or isophthalic acid to produce the terephthalic material. As yet, there is no evidence that such processes will be employed commercially.

Some smaller markets for xylene: chlorinated derivatives of Diamond Alkali, and a pre-emergence herbicide (Dachtal). Plasticizers remain a very minor outlet.

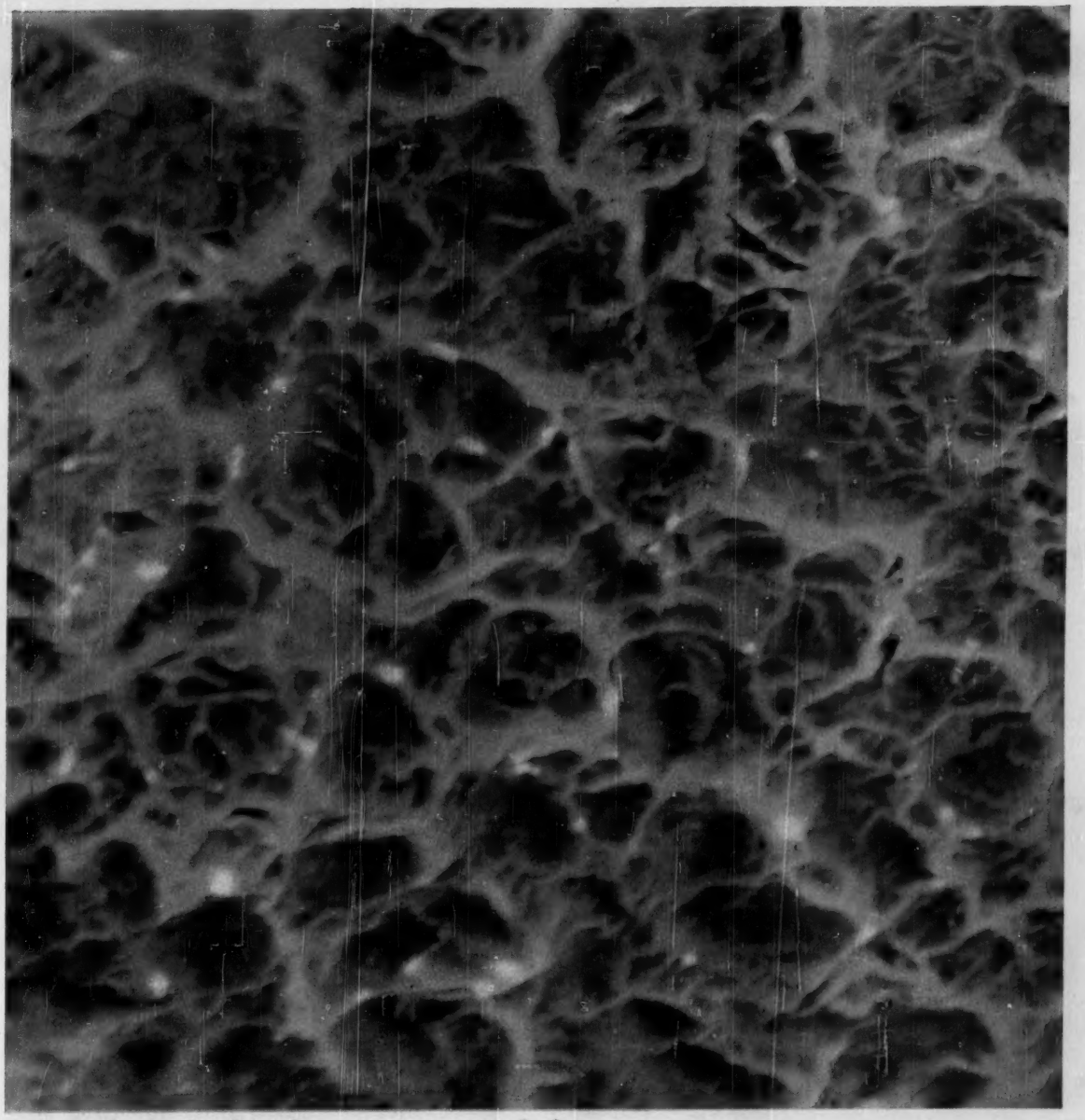
Petrochemicals-5

NAPHTHALENE BECOMES A MAJOR PETROCHEMICAL

The manufacture of naphthalene shows signs of becoming a major petrochemical operation as a result of several recent announcements of installation of units to produce it by hydrodealkylation of refinery streams, particularly catalytic cracker recycle stocks. The pressure for new sources of supply is evident from the capacity figures, which indicate that the potential supply from the coking industry amounts to about 360 million lb. on the basis of 60% of maximum recovery. In 1959, the domestic sources were supplemented by 59 million lb. of imports and, even at this level, naphthalene availability was restricted for phthalic anhydride conversion.

The contribution to naphthalene capacity that is planned by the petroleum operators almost equals the amount that was recovered from coal-tar sources in 1959, promising

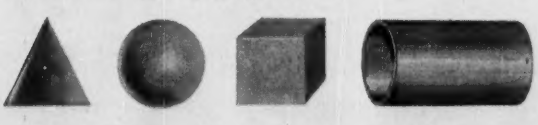
Continued on p. 60



Refractories confine heat for every process need when you

mix imagination with Alcoa Aluminas

Time and again, higher process heats have formed the key to new products, greater production, increased quality and lower costs. As temperatures climb, refractory performance becomes more and more critical . . . making it increasingly important to use refractories fortified with Alcoa® Aluminas. As the alumina content of a refractory material increases, these unique benefits occur: strength and stability increase under load at high temperatures . . . coefficient of expansion decreases . . . resistance to chemical attack improves . . . spalling, abrasion and fluxing decline . . . effective service life grows longer and longer. Happily, the first cost of high-alumina refractories is surprisingly low. *ALCOA does not make refractories.* However, we will gladly refer you to a reliable supplier who uses Alcoa Aluminas to make *finer* refractories. Write to: ALUMINUM COMPANY OF AMERICA, Chemicals Division, 706-M Alcoa Building, Pittsburgh 19, Pa.

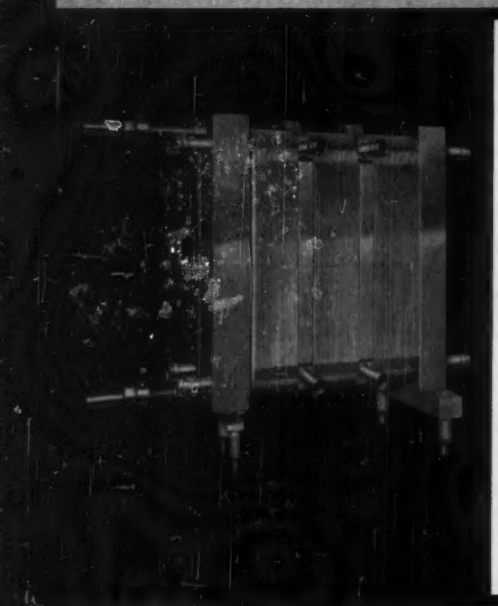


ALCOA CHEMICALS

ALUMINUM COMPANY OF AMERICA

De Laval tackles process problems

...economically!



Hic!

Many barrels of wine have barreled through our sturdy Plate Heat Exchangers. So, too, have vast quantities of orange juice, milk and beer. Between the stainless steel plates, pasteurization temperatures are quickly reached and closely held. Remarkably high exchange efficiencies are economically evident in heating, cooling and regenerative sections. High turbulence, even at low velocities, is assured by the corrugated plates of De Laval Plate Heat Exchangers. Differentials as low as 5°F in the exchange streams are practical.

Food applications have been a "natural" for the sanitary construction of these exchangers. But their performance efficiency and maintenance economy is earning more spots in rough industrial service. The reasons are simple and sound:

- Sturdy stainless steel gives the insurance of long, dependable, maintenance-free operation.
- Capacity is easily increased any time. Just add plates.
- Arrange for dual or triple-section operation by simply adding headers.
- Clean-in-place, as required; or open in minutes for full exposure of plate surfaces.
- Typical heat transfer coefficients are in the range of 600-750 Btu/hr-ft²-°F — often over 900!
- Full capacity range—to 1600 square feet of exchange area.
- The most compact heat exchange system available. Stands freely in small floor area and needs only piping connections.

For Further Information Write To Dept. C-12

DE LAVAL

THE DE LAVAL SEPARATOR COMPANY
Poughkeepsie, New York
5724 N. Pulaski, Chicago 46, Illinois

DE LAVAL PACIFIC COMPANY, Dept.
201 E. Millbrae Avenue, Millbrae, Calif.

CENTRIFUGES
PLATE HEAT EXCHANGERS
VIBRATING SCREENS
COMPLETE PROCESSES

Shake a Lot, Toss a Little ...Shake a Little, Toss a Lot

In seiving by hand, you intuitively adjust the amount and type of shaking and tossing to get optimum separation. Now this same full range of controlled motion is available in a high-capacity screen separator. Simply adjust three controls to obtain a predictable "3-D" screening action ranging from gentle nudging of easily-damaged products, to turbulent, intense exposure of powders, granules, or slurries to screen for rapid, efficient separations.

A review of the De Laval Syncro-Matic features reveals why it is rapidly finding use in such applications as:

- Scalping of liquid suspensions prior to centrifugal separation.
- Grading of fruits, nuts and diced vegetables.
- Thickening of wood pulp slurry.
- Classification of resin molding powders.
- Removal of spent grain in fermentation.
- Removal of fines from crystals.
- Separation of fibers from pulped food.

In all cases, the *particular* optimum combination of screening motion was determined by simple adjustment of control dials. When the De Laval Synchro-Matic is used for multiple separation processes, resetting of the motion controls is done in minutes. Positive-control action assures constant screening action regardless of load conditions.

The full versatility and effectiveness of the Syncro-Matic can be detailed to you by a De Laval representative. Drop us a line to have him call, but meanwhile, think about:

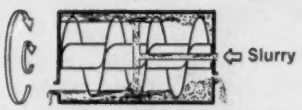
- Single, double or triple decks of easily-replaceable screens.
- "Infinite" range of calibrated control in *three* directions.
- Light, stainless steel construction.
- Quiet and almost vibrationless operation with few moving parts.

WATCH IT! YOUR NEURONS ARE STIFFENING!

"Electronic brains are not victims of habit. We humans, unfortunately, are. Life is easier when 'thinking' is channeled through well-worn familiar paths. That way, our conclusions seldom surprise us. And, like the hardening of our arteries, the neurons of our mind 'stiffen.'
"Do this. Be a **computer** for a day! Feed in the surprisingly **new** information on today's process equipment. Program it to point up the improvements **or complete changes** actually possible in your process. Naturally, we hope these limbered-up neurons will evaluate the information given here."

Fred Wheelwright, Industrial Sales Manager

2000G Centrifuge "Lies Down" to Tackle Continuous Separation of Slurries and Suspensions



Cylindrical Bowl

Conical Bowl

Minute solids particles to ½" lumps are instantly separated from liquid in a "2000G" environment. That's the centrifugal force generated by the De Laval "NX De-Sludger"—a hollow-bowl centrifuge that operates on a horizontal plane.

The continuous separation is effected by a screw conveyor which revolves slowly relative to the bowl wall, pushing solids to discharge ports at one end while the clarified liquid is discharged at the other.

Materials ranging from crushed pulps to mineral slurries are handled with equal ease by the De Laval "NX De-Sludger." Typical applications include "roughing" separation of liquid prior to conventional centrifuging, and controlled de-watering of slurries prior to further processing.

Relatively new, the De Laval "NX De-Sludgers" are replacing batch-settling and screening operations to give more effective trouble-free continuous separation. Design features include choice of cylindrical, conical or combination bowl types, adjustment of bowl liquid level and conveyor speed.

Would exposure to 2000G's plus continuous discharge solve a separation or concentration problem for you? We'll be happy to discuss it at no obligation. Just write!

to ease the tight supply of naphthalene once the petroleum units are in operation. The increasing demand for naphthalene abroad will tend to restrict exports to the U. S., so the petroleum-based output should also enable the domestic phthalic industry to rely upon U. S. sources for its major raw-material requirements.

The use of naphthalene in refining and other conversions such as beta-naphthol, tanning and surface-active agents is significant. Refined naphthalene amounted to 72 million lb. in 1959; 50 million went to the other uses. The major outlet is in phthalic anhydride manufacture. Representing 75% of the 484-lb./yr. total consumption in 1959, it took 362 million lb.

Naphthalene Capacity Million pounds/year, est.

Producer	Location	Capacity
From petroleum		
Ashland Oil	Catlettsburg, Ky.	75
Collier Carbon & Chemical	Los Angeles Calif.*	50
and Tidewater Oil	Wilmington, Del.*	100
Sun Oil	Toledo, Ohio*	100
	Total	325
From coal		
U. S. Steel, Koppers, Allied Chemical, Pittsburgh Coke & Chemical & others		610
	Grand total	935

* Under construction or planned.

Phthalic Capacity Million pounds/year, est.

Producer	Location	Capacity
Principally from naphthalene (phthalic anhydride only)		
Allied Chemical	Los Angeles, Calif.	25 (25*)
	Philadelphia, Pa.	100 (25*)
	Ironton, Ohio	35
	Chicago, Ill.	35
	Buffalo, N. Y.	25
American Cyanamid	Bridgeville, Pa.	65
W. R. Grace	Fords, N. J.	50 (50*)
Koppers	Kobuta, Pa.	20
Monsanto Chemical	St. Louis, Mo.	75
	Everett, Mass.	40
	Gloucester City, N. J.	35 (35*)
Pittsburgh Coke & Chemical	Neville Island, Pa.	35
Reichhold Chemicals	Detroit, Mich.	30
	Azusa, Calif.	16 (8*)
	Elizabeth, N. J.	30
	Newark, Ohio	60 (60*)
Sherwin-Williams	Kensington, Ill	7
Thompson Chemical	Pawtucket, R. I.	10 (10*)
Witco Chemical	Chicago, Ill.	20
	East Coast	30 (30*)
	Total	743 (243*)
From xylenes		
Amoco Chemicals	Joliet, Ill.[1]	60
Standard Oil (Calif.)	Richmond, Calif.[2]	65
	Grand total	868 (243*)

* That portion of the listed capacity that is under construction or planned.
[1] Includes benzoic acid, phthalic anhydride, iso and terephthalic acids.
[2] Includes 50 MM lbs isophthalic acid capacity.

Despite the relatively mature position of phthalic anhydride in the organic chemicals field, new plants now under construction or planned represent about a 30% increase to existing capacity. Some of the new construction has been prompted by the desire for integration on the part of consumers of phthalic anhydride. In other cases, the output has been designed primarily for merchant markets.

The major market outlets for phthalic are in alkyd resins and plasticizers. Alkyds took 147 million lb. in 1959 and plasticizers 145 million. The rest of the 374-million-lb. total consumption was accounted for by: dyes & pigments, 10 million lb.; exports, 4 million lb.; other, 30 million.

The alkyd industry has shown some signs of maturity, particularly in view of the recent development of water-based finishes that employ alternate raw materials. However, alkyds may be given further impetus through development of both solution and emulsion types of alkyd coatings.

Phthalates continue to be the standard measure for the plasticizer industry, benefiting from the continued growth of the vinyl resin field. As yet, there does not seem to be any major trend towards use of internally plasticized vinyl products.

Higher analogs of benzene such as durene and pseudocumene continue to receive attention as chemical raw materials. The functional compounds derived from these intermediates, such as polyhydric alcohols and polybasic acids are being explored in a variety of markets. One field of present interest for pyromellitic anhydride may be found in curing agents for epoxy resins.

Phthalic Anhydride Sources

Million pounds, est., 1959	
Naphthalene	294
O-Xylene	64
Total	358
Imports	16
Grand Total	374

ADDED SAFETY is an important benefit when you equip your loading rack with the only gear-driven swivel joint on the market. No danger of the operator slipping on wet or icy decking while pulling down a loading arm. No chance of arm dropping or rising unexpectedly to spill hot or caustic products. No counterbalance arms, cables or pulleys to endanger clearance on the platform. The entire loading operation is constantly controlled by this easy-to-crank joint.

TROUBLE-FREE SERVICE offers an equally important advantage. This gear-driven swivel joint incorporates all the proven features of C-E's popular US-Type Joint. It breaks like a union for quick, easy repairs on location without special tools. No need to disturb bearings when repacking. Wide-spaced bearings and non-split races last longer and permit greater foot/pound loading. Separate races can be reversed easily to double their life.

C-E Gear-Driven Swivel Joints are available in 2, 2½, 3 and 4 inch sizes — styles 3, 4, 5 and 6 — in mild steel or with stainless steel wettable parts.

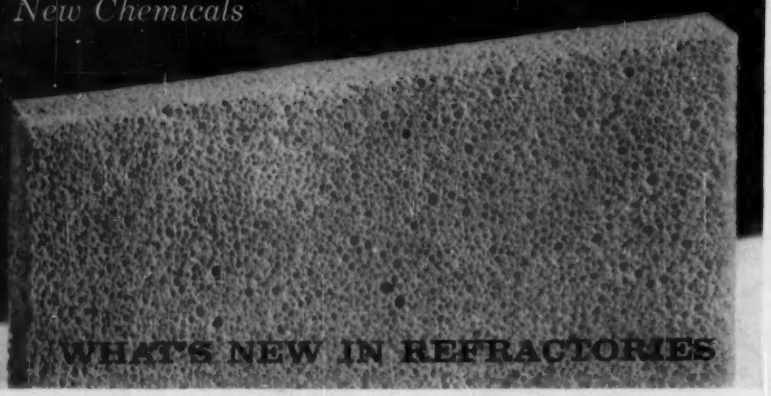
For more years of service, less maintenance expense and a safer loading rack, equip it entirely with Continental-Emsco's Gear-Driven Swivel Joints. There's a size and type to meet every requirement.

Write, call or wire for the full catalog and price information.

CONTINENTAL-EMSCO COMPANY
A Division of The Youngstown Sheet and Tube Company

Industrial Products Division
P. O. Box 359,
Dallas 21, Texas

SJ 04



Zirconium oxide sponge resists temperatures up to 4,200 F.

TiB_2, zirconium and halfnium oxides reach new peaks in heat resistance of refractory materials

Offering high strength and lightness, combined with increased heat and electrical resistivity, two new materials are now meeting the challenge of the space age. Their applications run the gamut from jet and rocket engines to electrical fixtures and insulating bricks.

▶**Lighter Than Water**—Although very similar to an ordinary kitchen sponge, the first—IBC 4200—has nothing to do with washing dishes.

Made chiefly of zirconium oxide plus some hafnium and calcium oxides, this insulating material possesses a cellular structure of uniformly interconnected pores that permit gases and liquids to pass through for purging and evacuation.

IBC brick can withstand temperatures up to 4,200 F. in vacuum, nitrogen, hydrogen and oxidizing atmospheres. Its temperature limit in a reducing atmosphere with carbon present is 3,000 F.

About half as dense as water, IBC is readily cut, sawed or filed. Presently used in a combination vacuum-atmosphere furnace that operates at 4,200 F. for sintering of high-temperature materials, IBC is also expected to find applications in space vehicles and in the nuclear field because of its stability, light weight and low heat conductivity. — **Ipsen Industries Inc., Rockford, Ill. 62A**

C. E. Ford, of National Carbon Co., shows huge titanium diboride cylinder.

▶**Cuts Aluminum Costs**—A new process, for which National Carbon has a patent pending, reduces the oxides of titanium and boron to a fine, high-purity powder that can be fabricated into various shapes.

This titanium diboride maintains a flexural strength of 35,000 psi. over a temperature range of 77-3,600 F. and has a high modulus of elasticity (60×10^6) that makes it similar to ceramic materials. Its weight is only 12% greater than alumina and half that of stainless steel. Because of these properties, titanium oxide can make lightweight ball and roller bearings for jet and rocket engines that operate at elevated temperatures.

With a 3,300 kg./mm.^{2} (Knoop) hardness, in the range of boron carbide, long regarded as the hardest man-made material, titanium diboride tools can cut hard metals at high speed and TiB_2 shear blades can cut rubber or plastics containing abrasive fillers.

Reportedly, titanium diboride has excellent resistance to oxidation at temperatures as high as 1,800 F., and a relatively low oxidation rate even at 2,500 F. Its inertness to molten aluminum, molten zinc and slags makes it all the more attractive for crucibles, pumps, funnel linings and valves.

Large TiB_2 cylinders as lead-in connections to the cells used in the production of aluminum reduce power losses through the pot lining itself by as much as 30 to 50%, because the electrical resistivity of this refractory ranges from 20 to 100 micro ohm/cm. over an 1,800 F. temperature span. Titanium diboride leads will permit new designs for aluminum cells that may significantly reduce the investment per ton of aluminum capacity in new facilities.— **National Carbon Co., Div. of Union Carbide Corp., New York. 62B**

Teflon fiber

Monofilament yarns for special fabrics find new uses for Teflon.

Teflon FEP-fluorocarbon monofilament fiber, available in 250- and 1,200-denier sizes will soon get into fields such as chemical distillation and gas demisting where wires of noble metals now are required.

In vacuum filters of window screen construction, where residue caking creates problems, the nonsticking Teflon will simplify and speed up cleaning. Previously, only multifilament yarns of Teflon fiber have been on the market. Now, fabrics made from monofilament fiber can be heat-treated to

prevent edge raveling—a major problem with fabrics woven from multifilament yarns.

Brushes made with bristles of the new monofilament can be dipped in any acid or solvent without damage. New multifilament yarns now come in sizes as small as 100 denier, the lightest weight yarn yet produced from Teflon.

These lighter multifilament yarns have applications in the medical field, may be woven into thin, highly effective filter fabrics for surgical masks and bandages. **—E. I. du Pont de Nemours & Co., Wilmington, Del. 62C**

Chemical intermediates

Fatty chain C-18 compounds now on the market.

Elaidyl alcohol, trans-octadec-9-enol, the *trans* isomer of ordinary oleyl alcohol, is a white solid that melts slightly above room temperature. Available at 99% purity, this alcohol is a standard for gas chromatography.

The elaidyl alcohol is synthesized from high-purity methyl oleate by saponification and isomerization, followed by re-esterification and sodium reduction. A 40,000-plate Apiezon capillary then separates the *cis* and *trans* isomers. — **Applied Science Laboratories Inc., State College, Pa. 63A**

Two fatty hydroxamic acids, oleyl and fatty C-16, are important chemical intermediates because they offer reactive OH and NH groups, in addition to a long fatty chain.

They are known to react with alkalis, metallic ion and acylating agents to give colored salts.

On heating, they form isocyanates, which can be reacted further with alcohols and amines to yield urethanes and ureas, respectively. With water, the isocyanates give carbamic acids.

Industrially, these fatty acids may be used for pigment dispersants, detergents, corrosion inhibitors, metal deactivators and chelating agents.—**Woburn Chemical Corp., Harrison, N. J. 63B**

Textile softener

Nonionic liquids lubricate fabrics, inhibit statics.

Compatible with resins, catalysts and dye fixatives, Sonofin 3639A is a low-cost softener and lubricant that gives uniform emulsions of less than 1-micron particle size.

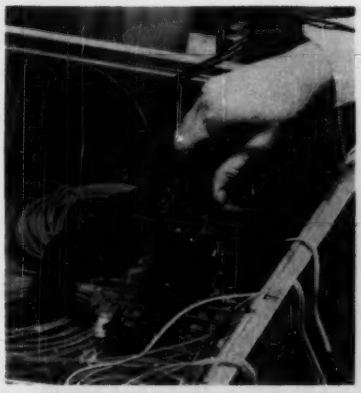
Undiluted, it may be added to the resin bath where it remains stable to the acids, alkalis and salts present. Resistant to oxidation and yellowing, even at elevated temperatures, Sonofin doesn't retain chlorine and won't create corrosion problems.

Based on the weight of the yarn or fabric, a 1-3% solution is adequate in most operations. With wash-and-wear and crease-resistant fabrics, it increases tear strength and crease recovery while at the same time minimizing friction between the threads. Improved wear and better sewability are the result.

In warp sizing of rayons, acetates and synthetics, Sonofin is reported to be an efficient plasticizer for resinous sizes, starches and gelatins.

► **Removes Lubricants** — Another nonionic liquid, Sonostat 60, imparts static inhibition to wool, rayon and synthetic substrates.

Readily emulsifiable by slight agitation with warm water, Sonostat scours heavily and assists in the removal of spinning lubricants that may be present on the stock. **—Sonneborn Chemical and Refining Corp., New York. 63C**



High-density polyethylene

Thermoplastic resists stress, is resistant to chemicals.

High-density polyethylene, Ameripol, has been developed from the Ziegler activated-catalyst system by a new process that imparts new highs in environmental stress-cracking resistance (SCR) and in temperature-embrittlement resistance, while maintaining the processing ease of conventional high-density polyethylene.

This new polyethylene is reported exceptionally suitable for blow-molded articles, wire and cable insulation and extruded pipes. With blow-molding proper-

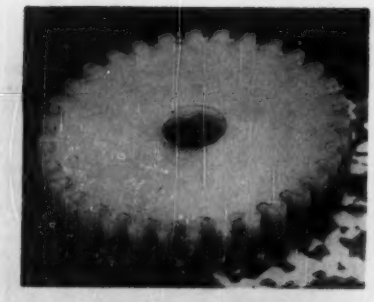
Newsworthy Chemicals

Zirconium oxide sponge withstands 4,200 F.....62A
Titanium diboride powder for fabricating process equipment.62B
Fluorocarbon-fiber wire may move in on noble metals.....62C
Oleyl alcohol isomer finds use in gas chromatography.....63A
Fatty hydroxamic acids serve as useful intermediates.....63B
Nonionic liquids aid in textiles manufacture.....63C
High-density polyethylene boasts new performance levels....63D
Vinylidene fluoride resin competes with steel, Teflon.....64A
Diatomite filter aid helps handle viscous liquids.....64B
Epoxy resins feature advantages in curing.....64C
Liquid admixture improves concrete, mortar.....64D
Pure dilauryl thiodipropionate available commercially.....64E
Catalyst carriers made of aluminum oxide have large pores...64F

More details, use Reader Service Card

ties that exceed present specifications, Ameripol containers are not only supposed to be better functionally, but are also easier to make than those of conventional high-density polyethylenes.

The three grades of Ameripol have molecular weights in the 50,000-100,000 range, at 0.95 density. The large resistance to stress cracking has been shown by ASTM tests in which two of the three available grades rated higher "hours-to-failure" than other polyethylenes. And thermal embrittlement tests indicate that the material can withstand elevated temperatures for more than 1,000 hr.—**Goodrich-Gulf Chemicals Inc., Cleveland.** **63D**



Teflon's latest competitor

New thermoplastic claims improved machining qualities outlives stainless steel.

Kynar is the latest product to join forces with the established Kel-F and Halon resins in trying to wrest a slice of the Teflon market.

Chemically, Kynar is a crystalline, high-molecular-weight polymer of vinylidene fluoride ($CH_2 = CF_2$) that gives a hard, slippery, whitish surface having long life expectancy in the most corrosive environments.

By halting polymerization when the molecular weight reaches approximately 500,000, Pennsalt Chemical has been able to make a product that extrudes readily, shows good machining qualities and can be molded, therefore, into complex shapes while using standard equipment. In these respects, Kynar is reported superior to Teflon.

▶**Service From −80 to 650 F.**—If polymerization is carried further, heat stability and hardness increase but the product becomes tougher to machine. So, Pennsalt offers Kynar in several molecular weight grades—as a white, free-flowing powder, pellets or organic dispersions.

Becoming brittle at −80 F., Kynar shows thermal stability at temperatures up to 650 F. where degradation to HF and a carbon skeleton begins. The resin won't support combustion and its water absorbency is as low as 0.04%

Laboratory tests show Kynar to be mechanically strong and tough, resistant to distortion and creep at high and low temperatures, and stable even under ultraviolet radiation.

Main uses are in equipment parts such as seals and gaskets; diaphragms and impellers for valves and pumps; tank linings and coatings. Kynar gaskets have been very successful in sealing tanks and lines that contain HF and H_2SO_4 mixtures. Lapp pump diaphragms showed no deformation after pumping for a month against 6,000 psi. back pressure.

And whereas Type 301 stainless steel compressor diaphragms quickly corroded and stress cracked when compressing perchloryl fluoride gas, similar diaphragms faced with a thin Kynar coating gave prolonged service without sign of corrosion or fatigue.

Because of its inertness to organic and inorganic acids and solvents, polyvinylidene fluoride makes a good packaging material for foods, pharmaceuticals, lubricants and propellants. Its high dielectric constant and dissipation factor make it a good high-temperature wire insulator.—**Pennsalt Chemical Corp., Philadelphia.** **64A**

For More Information about any item in this department, circle its code number on the Reader Service Postcard Page 151

Briefs

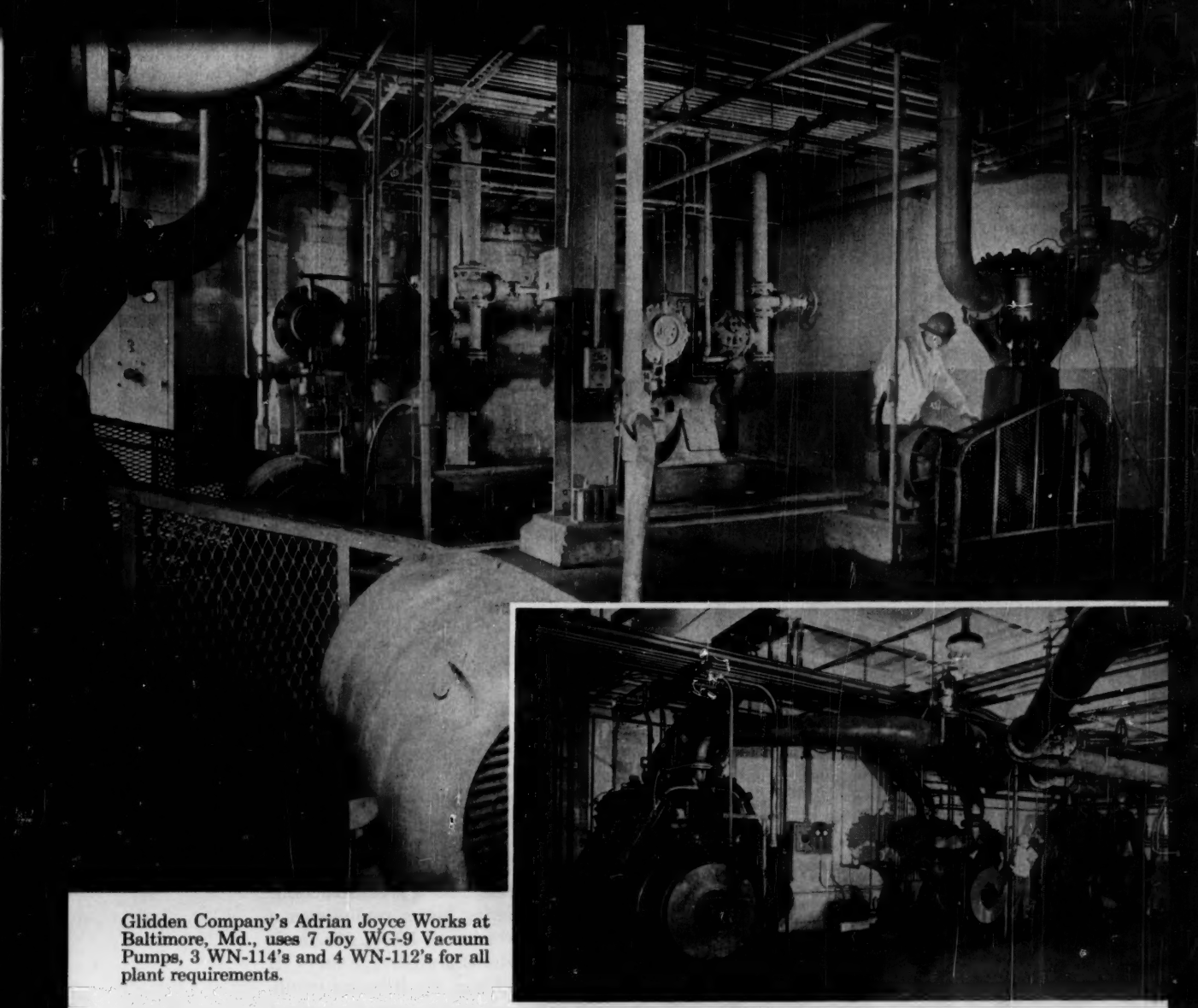
Diatomite filter aid called Celite 560, makes possible filtration of extremely viscous materials (plastics, resins, synthetic fibers and films) that could not previously be filtered because of low permeability of filter aids.—**Johns-Manville Corp., New York.** **64B**

Epoxy resin, Melpak E-200, cures at room temperature and satisfies requirements for most general-purpose potting, encapsulating and castings. With tensile and flexural strength of 8,000 and 16,000 psi., respectively, this epoxy is readily machinable and adheres to most plastics, metals and ceramics. Another resin, Melpak P-200, an unfilled polyester, is ideally suited for small castings or for encapsulating miniature assemblies. It may be removed from the mold one hour after casting.—**Melpar Inc., New York.** **64C**

Liquid admixture for concrete and mortar, Krete-X, speeds and improves the quality of cement work all year long and in all kinds of temperatures. By reducing the water ratio in concrete, this product induces high early strength and gives a denser structure. Acting as an antifreeze in cold weather, it permits the pouring of concrete and the laying of bricks throughout the winter.—**Truscon Laboratories, Detroit.** **64D**

Pure dilauryl thiodipropionate with an acid number below 1 and a melting range of 37-40 C. is available in commercial quantities. Product acts as a stabilizer and antioxidant for polypropylene, edible fats and oils.—**Daniel H. Price Inc., New York.** **64E**

Large-pore catalyst carriers made of fused aluminum oxide in spherical, pelletized and granular forms, permit gases or liquids to enter and diffuse within the structure of the carrier, providing optimum reaction control. These carriers are free of chemical poisons such as iron, chloride and sulfur.—**Norton Co., Worcester, Mass.** **64F**



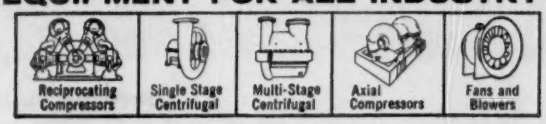
Glidden Company's Adrian Joyce Works at Baltimore, Md., uses 7 Joy WG-9 Vacuum Pumps, 3 WN-114's and 4 WN-112's for all plant requirements.

FOURTEEN JOY COMPRESSORS SUPPLY VACUUM, PLANT AND PROCESS AIR AT GLIDDEN'S ADRIAN JOYCE WORKS

The Glidden Company's modern Adrian Joyce Works relies on fourteen Joy compressors to provide all of the air requirements, ranging from 25" vacuum service to 30 pound process air and 100 pound plant air. The plant converts ilmenite to titanium dioxide by the sulfate process, which involves the use of sulphuric acid as a reducing agent. During the three years the plant has been operating, all fourteen Joy machines have stayed on the line with a minimum of downtime for maintenance.

Joy compressors are built for the rugged duty typical of chemical plants. Heavy casings and conservative rod loadings enable them to easily handle air and gases for extended periods of continuous service. Joy can provide reciprocating machines in standard or oil-free constructions, axial and centrifugal compressors in sizes from 15 to 15,000 hp. Consult your Joy representative whenever you need a compressor. For complete information on the Joy line, write for Bulletin 2561-11.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY

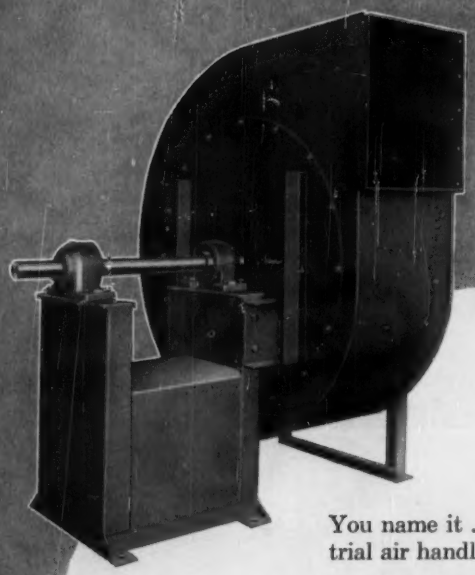


JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

How does industry rate CLARAGE?



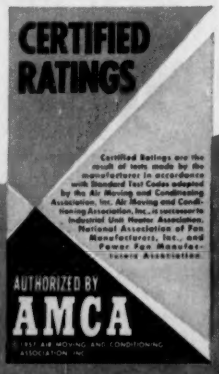
EXAMPLE:
Over 1000 Clarage fans of this type are serving one manufacturer alone.

RE-ORDERS . . . RE-ORDERS . . . RE-ORDERS

You name it . . . Clarage has it for virtually any industrial air handling assignment.

Take the Type XL Fan shown. It's built in 16 sizes and four arrangements for volumes to 130,000 CFM, temperatures to 1000°F., pressures to 18″. AMCA Certified Rating Seal applies to the three different wheels available —open, rim, and backplate types.

In the Clarage tradition of heavier duty construction, here is *quality* equipment assuring better results over a longer period of service. No wonder all 100 of America's 100 largest industrial corporations are Clarage users. If you too are after air handling and conditioning equipment that has what it takes—in every respect—contact our nearest sales engineering office.



Dependable equipment for making air your servant

CLARAGE FAN COMPANY

Kalamazoo, Michigan

SALES ENGINEERING OFFICES IN ALL PRINCIPAL CITIES • IN CANADA: Canada Fans, Ltd., [illegible]

ENGELHARD ANNOUNCES K and DH SERIES CATALYSTS FOR ACETYLENE REMOVAL FROM GASES

A SERIES OF PRECIOUS METAL CATALYSTS OPERATING AT SPACE VELOCITIES UP TO 7000 VOLUMES OF GAS PER VOLUME OF CATALYST PER HOUR. PLANT-PROVED for...

ETHYLENE PURIFICATION	Used in 11 U. S. and European plants
PROPYLENE PURIFICATION	Engelhard catalysts remove propadiene as well as methyl-acetylene
COKE OVEN GAS	Acetylene removal from streams containing up to 150 ppm. carbonyl sulfide. Ethylene content preserved for synthesis purposes
METHANOL SYNTHESIS GAS	Acetylene removed to 1 ppm. Ethylene content of stream increases

For full details, write for Brochure E-1

Engelhard catalysts are manufactured in the United States, Italy and England.

LEADERS IN PRECIOUS METALS

CATALYSTS FOR OVER THIRTY YEARS

ENGELHARD

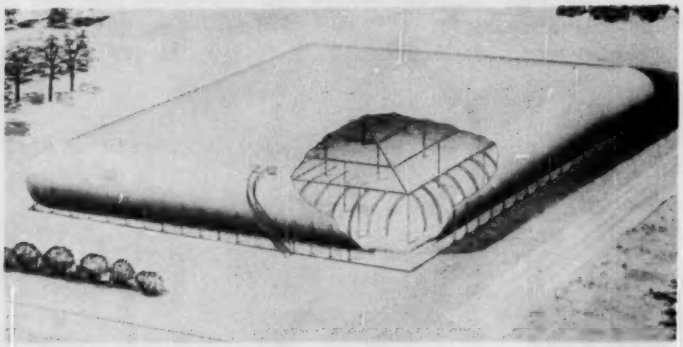
INDUSTRIES, INC.

CHEMICAL DIVISION

113 ASTOR STREET · NEWARK 2, NEW JERSEY

SALES OFFICES THROUGHOUT THE WORLD.

If this tank were any lower, it would be underground



No square foot of tank storage space goes to waste with this new bulk-liquid storage tank. Dubbed the Cylindroid, new tank can be constructed to fit the size and shape of square or rectangular industrial lots. Cylindroid is claimed to have greater capacity, cost less, and be more easily screened by landscaping, than a cylindrical tank on the same plot. Lightweight, tank can be erected on the site by a small crew with light equipment. All welding is down-hand.—**Graver Tank and Mfg. Co., E. Chicago.** **68A**

Fold-away tank

Rubber unit converts flat-bed truck or trailer into tanker.

A reinforced rubber fold-away tank can convert flat-bed trucks and trailers into tankers capable of carrying up to 3,000 gal. of liquid. The only modification required on a truck is the installation of a few metal clamps and fiber webbing to hold the unit in place.

Tank size ranges 500 to 3,000 gal. in increments of 500 gal. Smallest tank weighs 208 lb.; largest, 871 lb. Loaded with water, 3,000-gal. tank weighs in at 25,870 lb.

Tanks have already been tested in over-the-road service, carrying liquid fertilizer. Suitable for any liquids, they can receive a plastic liner that is impervious to chemicals when the material being transported is corrosive or must not come in contact with the rubber, as with foodstuffs.

Tank walls are built up with 4 plies of nylon tire cord, 2 plies of woven fabric. Tanks will withstand 30 psi., which is greater than any operating pressure. The ends are closed with belted aluminum clamps that include the filling valve and pressure gage.—**Gates Rubber Co., Denver.** **68B**

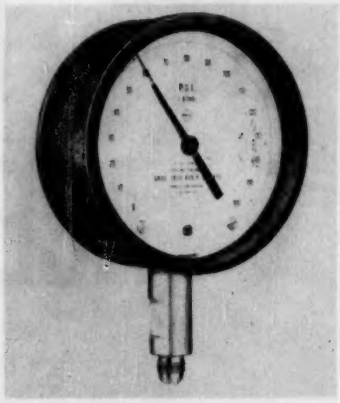
Gasoline fork truck

One-ton capacity unit has 49-hp. engine, pneumatic tires.

Designated the CY 20, a new gas-powered fork truck is equipped with pneumatic tires for outside operation over gravel and semi-paved surfaces. Dual-drive tires and wide profile tires are available as optional equipment.

Powered by a 49-hp. engine, the truck will start and stop on a 37.5% grade with a 2,000-lb. load. Operator controls lift and tilt with one lever; both operations can be done simultaneously.

Either automatic or standard transmission is available. The standard unit has a single-disk dry clutch plate that can be changed by simply removing a floor plate and front load panel, opening a split clutch housing.—**Clark Equipment Co., Battle Creek, Mich.** **68C**

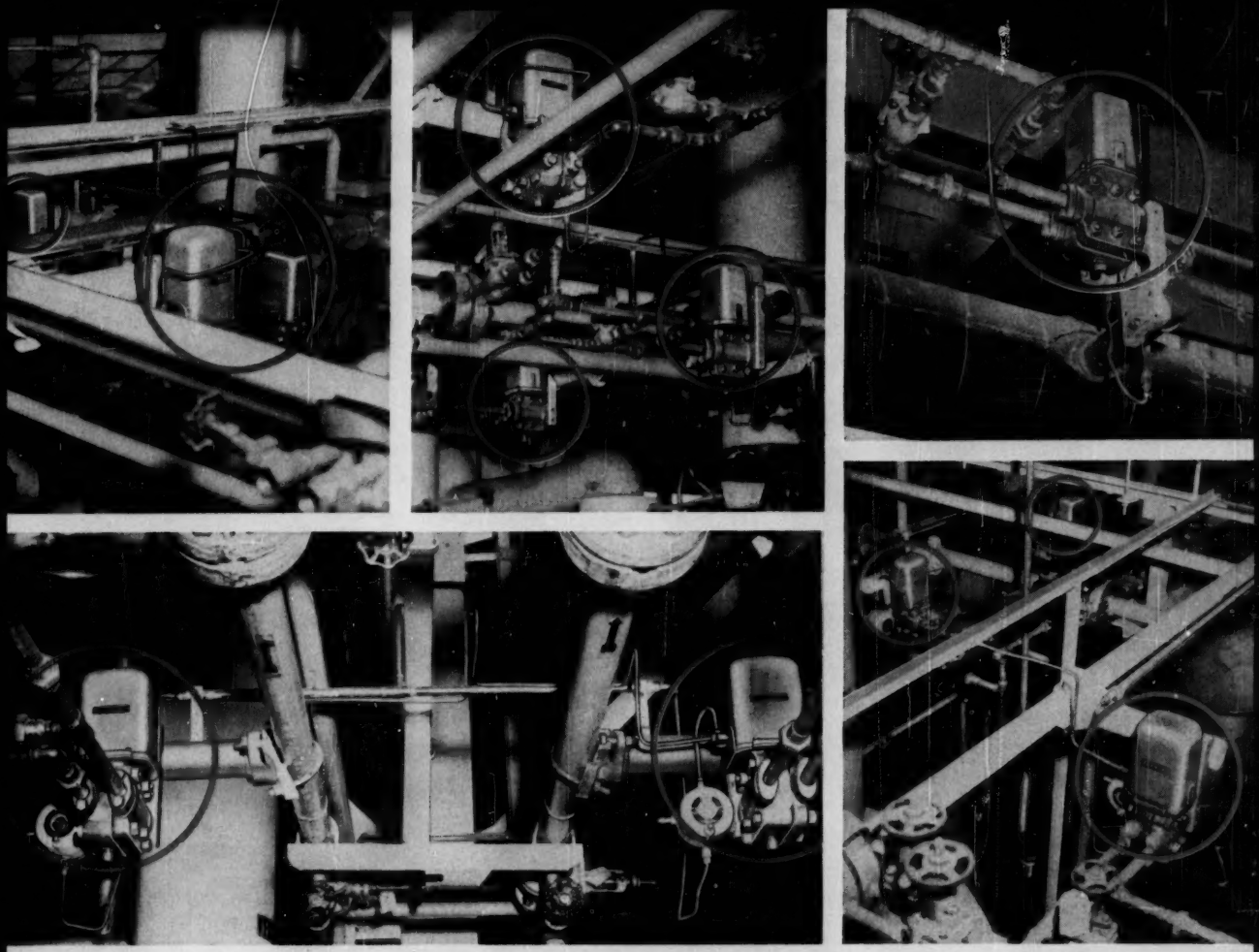


Pressure test-gage

Temperature-compensated unit is accurate from poles to tropics.

A new temperature-compensated test-gage is said to maintain a high degree of accuracy over polar to tropical temperature ranges. A patented link mechanism corrects for zero-shift error resulting from expansion and shrinkage of movement and socket materials. Link is built of metals whose thermal expansion rates complement each other, producing the required linear correction.

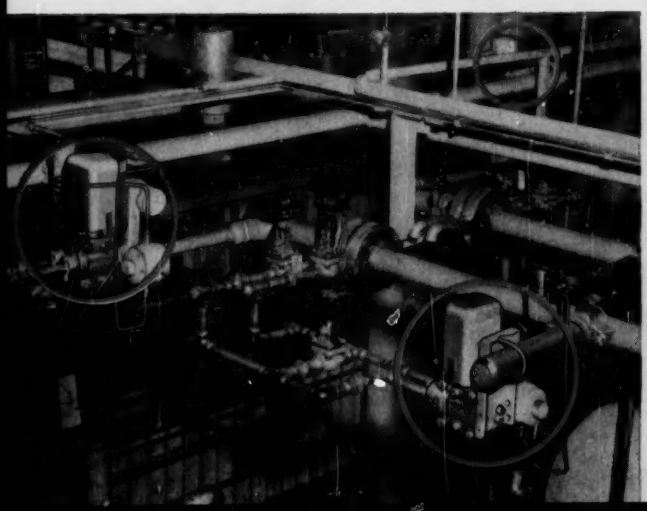
Temperature compensation is also built into the bourdon tube, which is made of a high-nickel alloy that minimizes the effect of temperature on the spring rate. Gages are available in pressure



A few of the more than 100 Foxboro d/p Cell Flow Transmitters installed at Missouri Chemical Works of Hercules Powder Company, Louisiana, Missouri.

Hercules' Missouri Chemical Works reports:

"Foxboro d/p Cells* always accurate . . . never need re-calibration"



At Hercules Powder Company's 540-acre Missouri Chemical Works, there are over 100 Foxboro d/p Cell Transmitters in operation today — providing high-speed flow measurement and transmission throughout the ammonia, formaldehyde, methanol and pentaerythritol plants.

"Reliability is the big thing," according to Hercules instrument engineer J. J. VanSchaik. "We can install a Foxboro d/p Cell and forget it. Once it's calibrated, we know it'll stay that way. We never even stock spare parts."

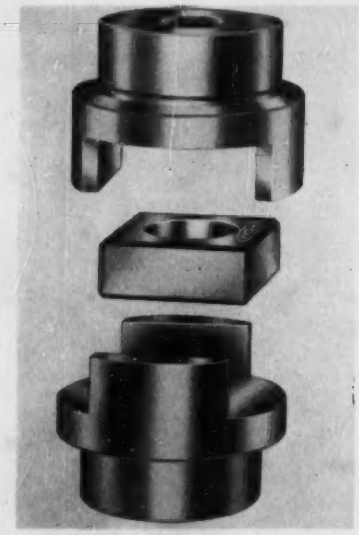
Hercules especially likes the Foxboro d/p Cell for flow control. "Gives us closer control," says instrument engineer H. McCombie. "Eliminates one possible source of inaccuracy and maintenance trouble in the control loop."

Let Hercules' experience be your experience — with Foxboro d/p Cell Transmitters as the basis for your control system. Write for full details in Bulletin 13-11A. **The Foxboro Company, 3612 Neponset Avenue, Foxboro, Massachusetts.**

*Reg. U. S. Pat. Off.

FOXBORO
REG. U.S. PAT. OFF.
FIRST IN FLOW

ranges of 0-160, 0-600, 0-5,000 and 0-10,000 psi., for test benches, portable test instruments or on instrument panels.—**U. S. Gauge Div., American Machine & Metals, Inc., Sellersville, Pa.** **68D**



Flexible coupling

Oil-impregnated center member lubricates bearing surfaces.

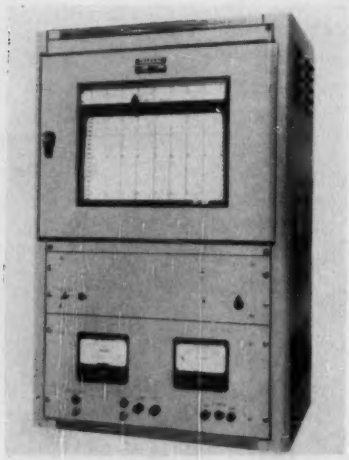
A newly designed flexible coupling is said to possess lifetime lubrication for bearing surfaces. Three-piece unit has special center member made of sintered steel. Containing a multitude of capillary passages, the member absorbs and retains high-grade lubricating oil for long periods.

The new unit will absorb the same amount of shaft misalignment as previous standard units. In addition, it is said to have greater torque.—**Zurn Industries Inc., Erie, Pa.** **70A**

For More Information about any item in this department, circle its code number on the Reader Service Postcard (Page 151)

Readers' choice

Reader service inquiries provide a handy guide to new equipment items that most interest you, the reader—and an unpredictable group you are. To let you know which equipment interested you most, the ones that were rated tops by you over the past year will be featured in a special roundup in this department next issue. —Ed.

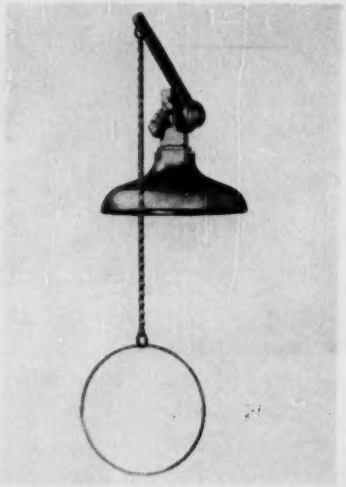


Vacuum gage

Ionization unit measures wide range on a single scale.

Vacuums from 10^{-3} to 10^{-10} mm. Hg are measured on a single scale, without range changing, in a new recording ionization gage with logarithmic output. Single-scale feature is said to make the instrument suitable for monitoring and controlling processes for up to 200 hr. or more without operator attention.

Known as Televac, the instrument can be used to control a number of different pressure values within the range cited; it can also provide proportional control if pressure rise or fall is rapid. One chart is sufficient for 240 hr. of continuous operation, monitoring, control.—**The Fredericks Co., Bethayres, Pa.** **70B**



Safety shower

Pull once for 34-gpm. deluge, a second time to shut off flow.

An emergency drench shower assembly has a rachet-type quick-opening ball valve that can instantly release 34 gpm. of water, under 40 psi. pressure. The rachet action eliminates any chance of valve drift that might cut down the flow during the emergency. One short tug on the ring starts the shower—it runs until the ring is pulled again.

The shower head is chrome-finish cast brass with a 10-in. adjustable face. Models are available for vertical or horizontal water supply. Functional parts are made of red brass; the valve spring is stainless steel.—**Haws Drinking Faucet Co., Berkeley, Calif.** **70C**

Moisture analyzer

Separate modules can sample and strip, measure, indicate.

A new electrolytic moisture analyzer that measures moisture in liquids and gases consists of three modules:

A precision liquid-sampling system, maintaining sample flow regu-

More New Equipment (Continued on page 124)

ordinary?

Soda ash might be considered an ordinary chemical. But, add three score and more years of experience in producing it, transporting it, studying it in use. Combine with mature and alert technical service. Crystallize with an understanding of the growing needs of industry on the move, and you have the formula for an extra-ordinary chemical . . .

Wyandotte Soda Ash

MAIL THIS CARD FOR MORE DATA ON SODA ASH

ANOTHER WYANDOTTE KEY CHEMICAL

Yes

CUT OUT, FOLD, STAPLE, AND MAIL TODAY!

Send technical data on Wyandotte ☐ light soda ash ☐ dense soda ash grades. Include price sheets on ☐ carload quantities ☐ L.C.L. quantities. ☐ I'd also like information on slurry handling of soda ash.

I use soda ash for_____

NAME_____

TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

(FOLD HERE ALONG LINE, THIS SIDE OUT)

WYANDOTTE CHEMICALS
MICHIGAN ALKALI DIVISION
Pacing Progress with Creative Chemistry®

BUSINESS REPLY MAIL
No postage stamp necessary if mailed in the United States

FIRST CLASS PERMIT No. 1
Wyandotte, Mich.

POSTAGE WILL BE PAID BY

WYANDOTTE CHEMICALS CORPORATION
MICHIGAN ALKALI DIVISION
WYANDOTTE, MICHIGAN

GAULIN GTA

(Gaulin Technical Assistance)

Takes The Risk Out Of Performance

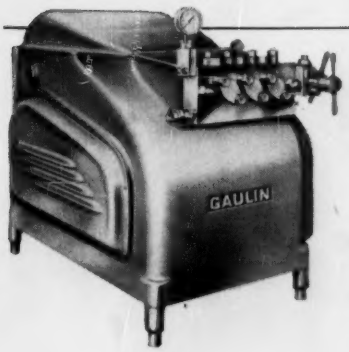
...Helps Cut Costs, Too.

GTA Bulletins

Technical Assistance

Laboratory Evaluation

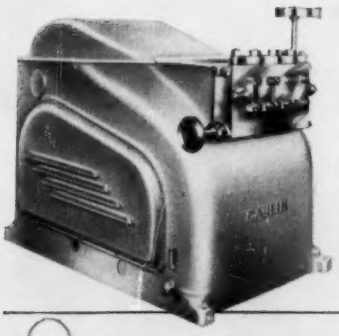
GAULIN GTA provides free technical data, experienced advice and laboratory evaluation. Assures the right equipment for the process . . . provides dollar savings.



Gaulin Homogenizers

and SUB-MICRON DISPERSERS reduce ingredients to finer, more uniform particle size.

Gaulin Homogenizers and Sub-Micron Dispersers disperse, emulsify and blend products reducing them to their ultimate particle size. They improve product uniformity, stop separation, assure more stable emulsions, accent taste, stop color separation. Ask for Bulletins — Homogenizers H-55; Sub-Micron Dispersers SMD-55.



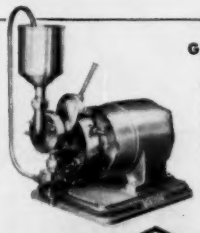
Gaulin High Pressure Pumps

handle all types of liquids and densities of fluids . . . deliver measured flow in metering applications.

These rugged, heavy-duty pumps are built to minimize operating, inspection and maintenance costs. Capacities to 7500 GPH . . . pressures to 12,000 PSI. Well area can be gasketed to provide maximum safety in handling hazardous materials. Write for Bulletin P-55.

GAULIN LABORATORY HOMOGENIZER

Minimum sample one pint; capacity 15 GPH; pressures up to 8000 PSI. Available on rental basis of only $75.00 per month. Ask for Bulletin LH-55.



GAULIN RE COLLOID MILL

Two-stage design provides continuous micrometer control for producing superior emulsions or dispersions. Available on rental basis of only $75.00 per month. Ask for Bulletin C-57.

World's largest manufacturer of stainless steel reciprocating, rotary, pressure exchange pumps, dispersers, homogenizers and colloid mills.

Gaulin TRADE MARK

MANTON Gaulin

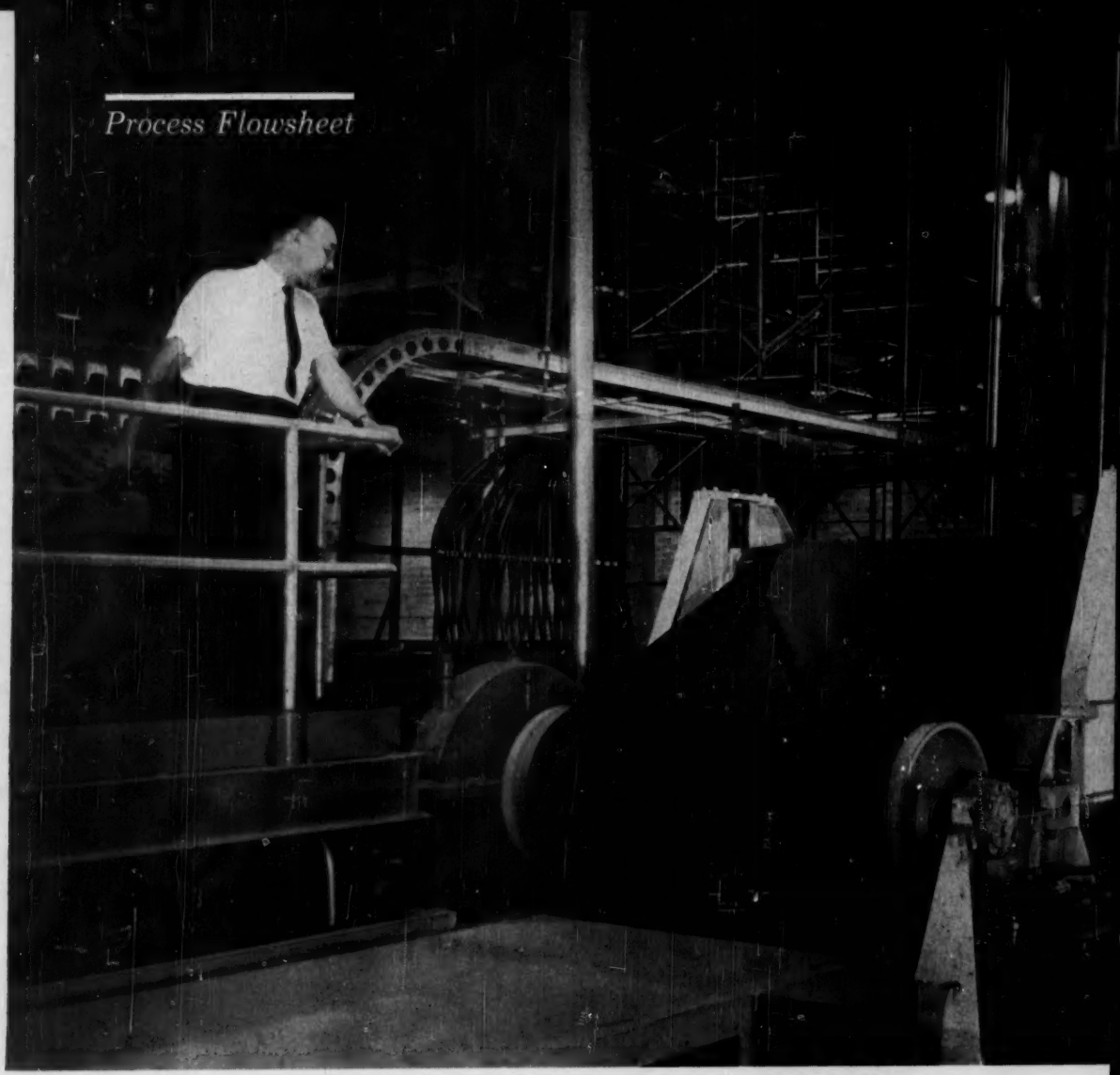
71 Garden Street, Everett 49, Mass.

Ask GTA...

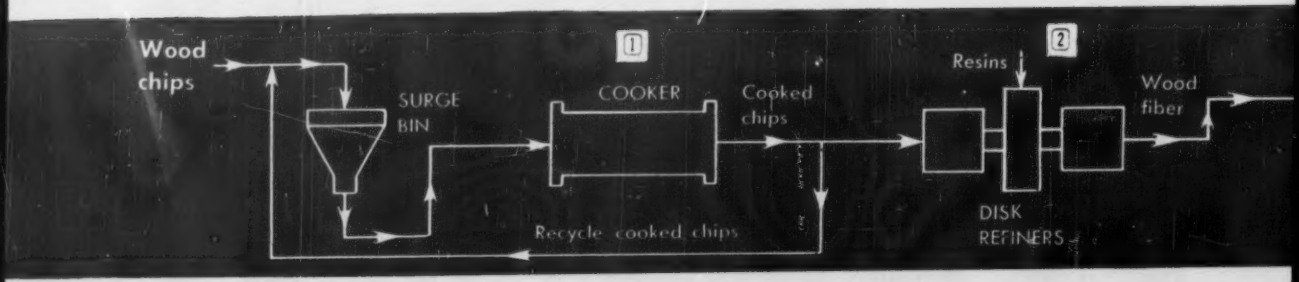
Gaulin Technical Assistance—for data on the complete Gaulin line: Homogenizers, Colloid Mills, Submicron Disperser, Triplex High Pressure Pumps and HX Pumps. Get GTA from your nearest Manton-Gaulin Representative . . .

Akron 8, Ohio
White Industrial Sales and Equipment Company
919 Second National Bldg.
Birmingham 6, Alabama
D. B. Gooch Associates, Inc.
5018 First Avenue, North
Boston, Mass.
Joseph H. Bertram & Company, Inc.
570 Hillside Avenue
Needham Heights 94, Mass.
Buffalo 6, N. Y.
A. W. Johnston Co.
2021 Clinton St.
Calgary, Alberta
Harvey Carruthers, Limited
122 17th Avenue, S.E.
Charleston 1, West Va.
White Industrial Sales and Equipment Company
1033 Quarrier Bldg.
Chicago 6, Ill.
Fuente and Webster Inc.
549 West Randolph St.
Cincinnati 2, Ohio
White Industrial Sales and Equipment Company
140 West Sixth St.
Clearwater, Fla.
Johnson Roney II and Associates
P. O. Box 26
Cleveland 20, Ohio
White Industrial Sales and Equipment Company
3639 Lee Road
Detroit 36, Mich.
H. A. Reed Company
19465 James Couzens Highway
Denver 18, Colorado
Alldredge & McCabe
847 East 17th Ave.
Houston 2, Texas
Edward Soph Company
768A M & M Bldg.
Indianapolis, Indiana
Avels Sales & Engineering Co.
1407 E. Riverside Dr.
Los Angeles 39, Calif.
E. M. Underwood and Company
2901 Rowena Avenue
Minneapolis 3, Minn.
George R. Mellema Co.
620 Plymouth Bldg.
Montreal, P. Q.
Richardson Agencies Ltd.
1244 Bois Franc Blvd.
St. Laurent, Montreal
Newark, New Jersey
Frederick E. Herstein & Associates
Benninger Building
1429 Route 22
Mountainside, N. J.
New York City 24, N. Y.
Kenneth S. Valentine Inc.
111 West 83rd St.
Oakland 11, California
E. M. Underwood and Company
4385 Piedmont Ave.
Philadelphia, Pennsylvania
R. W. Fox Company
P. O. Box 196
Newtown Square, Pa.
Pittsburgh 22, Pa.
White Ind. Sales and Equipment Co.
612 Farmers Bank Bldg.
Portland 14, Oregon
The Burhans-Sharpe Co.
Weatherly Building
St. Louis 8, Missouri
Wharton L. Peters Machinery Company
3863 West Pine Blvd.
Seattle 4, Washington
The Burhans-Sharpe Co.
1731 First Avenue, S.
Toronto, Ontario
Richardson Agencies Ltd.
164 Bentworth Ave.
Postal Address: P. O. Box 8, Station T,
Toronto 19, Ontario
Tulsa, Oklahoma
Edward Soph Company
202 East 18th St.
Vancouver 9, B. C.
Harvey Carruthers, Limited
1639 West 5th St.
West Hartford 7, Conn.
Joseph H. Bertram & Company, Inc.
998 Farmington Avenue

Process Flowsheet



[5] **Vacuum felters, representing heart of the process, convert dry fiber into a multi-layer mat. Following four . . .**

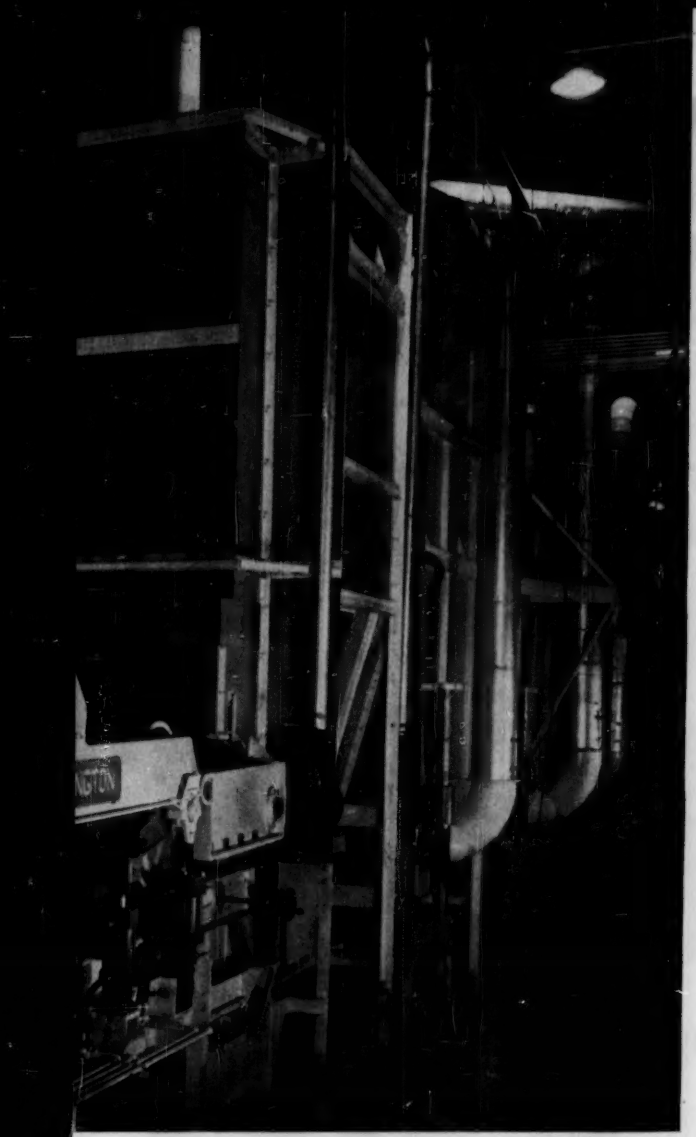


Hardboard Plant Boasts Modern Look

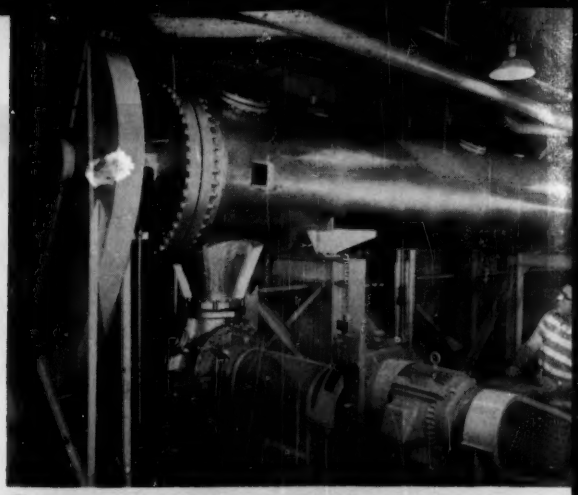
Featuring high capacity and a streamlined process, new Bowater Board Co. plant draws the spotlight in the hardboard industry.

N. P. CHOPEY, *Assistant Editor*

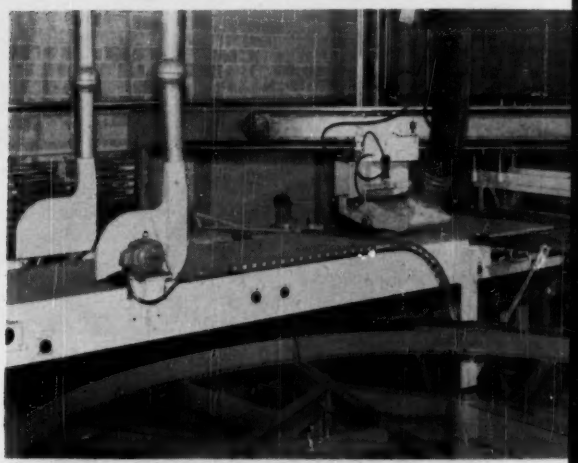
Unfold Flowsheet



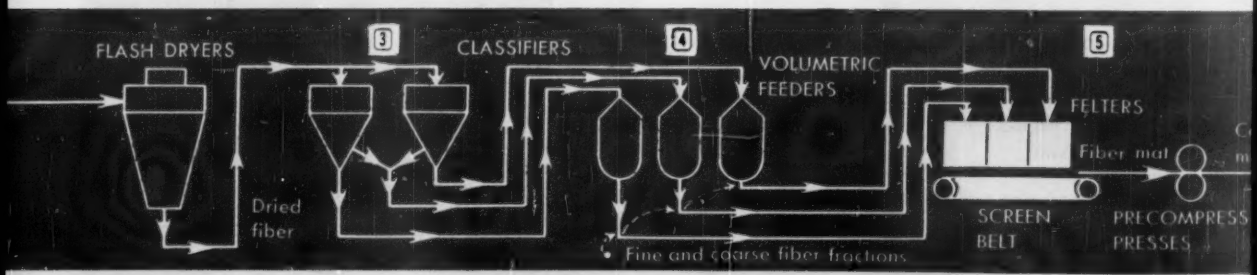
. . . felting steps, mat is precompressed at 300 lb./linear in.



1 Cooker steams hardwood chips for about 5 min. at 30 prepares them for subsequent conversion to wood fiber. steam pressure in the stainless-steel vessel is up to



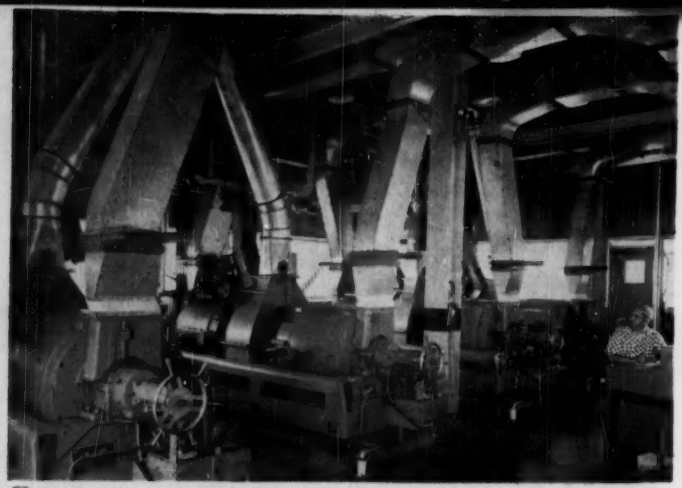
6 Saws operating at high speed trim the edges of the pre mat and cut it into required lengths. The individual mat deposited on steel caul plates and conveyed to the pres



A first-class example of modern thinking in hardboard production is represented by Bowater Board Co.'s new 500,000-sq. ft./day plant at Catawba, S. C. Initially started up last June, the facility boasts one of the fastest production cycles of any hardboard plant in the world, uses a unique version of the relatively new dry process for hardboard manufacture. Included is a continuous vacuum-felting operation, followed by pressing, which leads to high stability in the finished board.

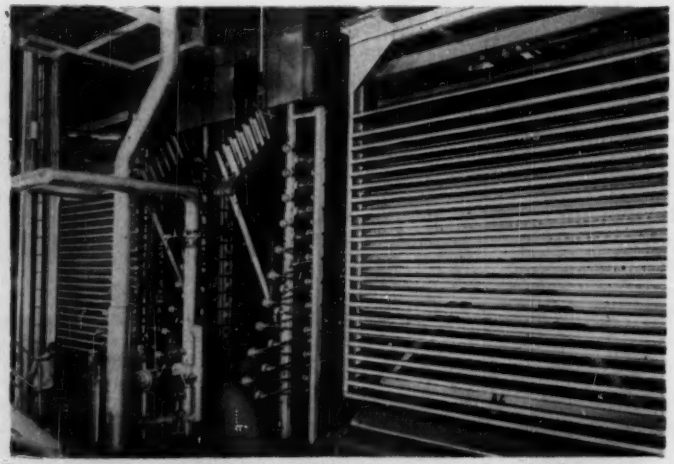
The plant receives selected species of southern hardwood, which are debarked and chipped to provide feed for subsequent fiber preparation and felting. Hardwood consumption rate is about 50,000 cords/yr. The board product—smooth on both sides and available in various densities, surfaces, compositions and dimensions—finds use in making furniture, paneling and similar items.

▶ **New Process, Newer Version**—The dry process for hardboard production eliminates need for wa-

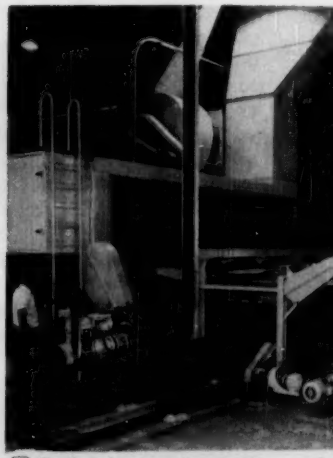


[2] **Disk refiners** reduce cooked chips to wood fiber. Resins may also be added here to impart specific properties. Each refiner is powered by a pair of motors that drive counter-rotating disks.

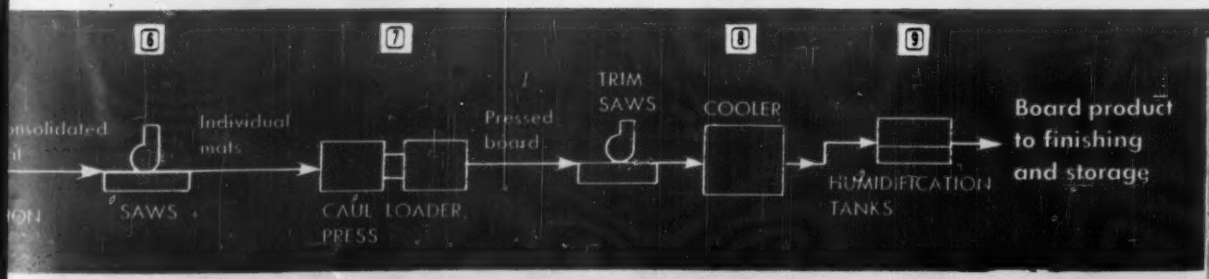
[3] **Classifying** of wood fibers is after the fibers have passed t automatically transfer fibers t



[7] **Press,** center, takes full load of 20 accumulated mats from press charger, left, and produces uniform pressed hardboard. Unloader, right, withdraws the hardboard product and separates the steel cauls.



[8] **Cooler** lowers temperature of unloader and passed by a second 350 F., are cooled by air circulat



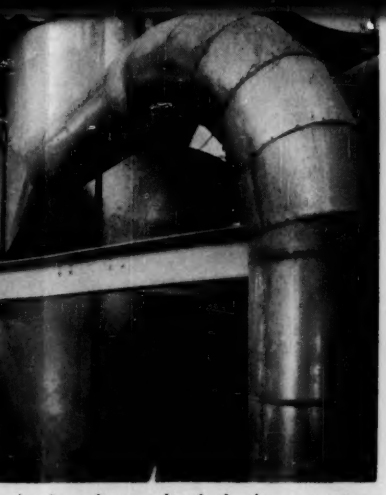
ter to convey wood fibers before they are transformed into board. Bowater developed its own refinement of the dry process, piloted it in a 17-month program in Oregon. Part of the equipment that is used was designed by the firm.

An upstream feature of the processing sequence t Catawba is a high-pressure pneumatic conveyng system for the wood chips. The chips are ooked, converted into fiber and combined with esin in disk refiners, and then dried.

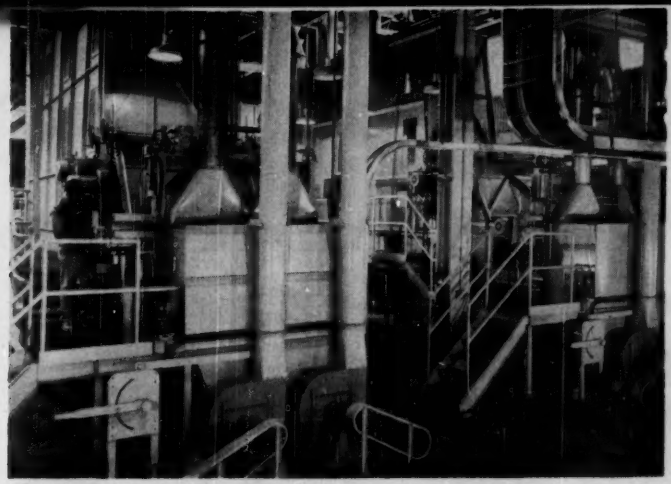
To handle the dried fibers, Bowater has installed a setup that features volumetric feeders and a pneumatic system with oscillating nozzles. The fibers are deposited on a moving wire screen that travels over suction boxes, thus building up a continuous multi-layer mat.

The mat is precompressed, trimmed and then pressed into board form. Additional trimming, plus cooling, humidification and finishing complete the process.

Exte



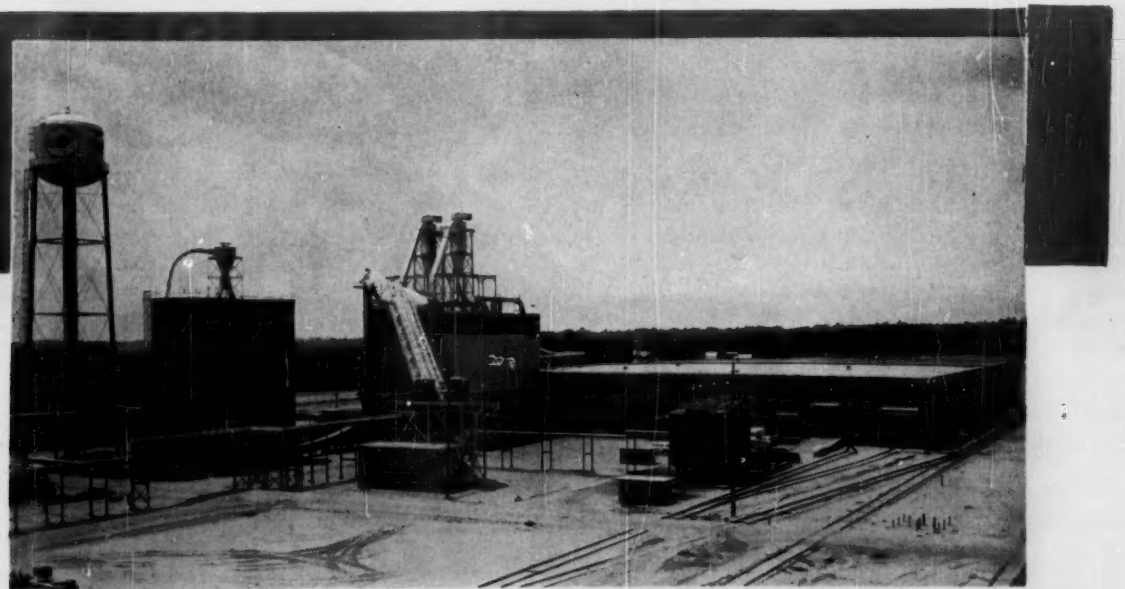
s is done by mechanical air separators, sed through flash dryers. Separators rs to appropriate volumetric feeders.



4 **Volumetric feeders** serve for both storage and metering. Two handle coarse fiber and a third handles fine fiber. They disperse the coarse and fine material in proper ratio for the desired product.

e of boards after they have left press cond set of trim saws. Boards enter at rculation and then go to humidification.

9 **Humidification tanks** bring board product to desired moisture level for particular end use. Product is then ready for final sawing and sanding, followed by steel-strapping and storage on pallets.



Exterior view of plant shows chip storage silos at left, flash dryers at left center, resin storage tanks at right.

DeZURIK VALVES....

...so much to offer on any installation!

With their easy operation, dead tight shut off, freedom from lubrication and other maintenance, DeZurik Valves offer still more advantages to the processing plant where corrosion, erosion or contamination is a factor.

A wide variety of materials is available for plug facings and valve bodies, allowing an almost "custom-designed" DeZurik Valve.

Plugs can be faced with Neoprene, Hycar, Teflon, Hypalon, Viton and other compounds which offer resistance to the deteriorating action of most chemical services. Metal faced plugs are available for use on extremely high temperature services.

Valve bodies are available in semi-steel, bronze, acid resisting bronze, Ni-Resist, aluminum, carbon steel, ductile iron, stainless steel, Alloy 20, Monel, nickel and other alloys. They can also be supplied with plastic coatings and hard or soft rubber linings.

Whatever problems *your* applications present, there's sure to be a DeZurik Valve that will handle it easier, better, with less trouble, longer! Why not ask the DeZurik representative in your area, or write for details?

DeZURIK CORPORATION
SARTELL, MINNESOTA

Switch Costly Mixing Operations to a Paying Basis with CONTROLLED DISPERSION

There's nothing new about controlled dispersion . . . except the growing need for it.

A Familiar Mixing Dilemma

If you mix dry solids or semi-solids, chances are you have felt this need first hand—in the squeeze between rising material costs and increased "front office" demands for better, more uniform blends—faster and with less material waste.

That's a big order and more and more processors have found that it's *too* big to be met with obsolete mixing equipment. It takes *more* than a simple stirring, tumbling an agitator action *can give*—to produce a blend of materials that is capable of converting a red figure mixing operation into a *new source for profit control.*

The Mulling Principle

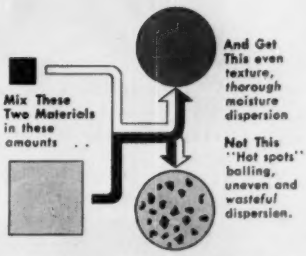
The Simpson Mix-Muller is *specifically designed* to *put you in control* of mixed properties. You get a unique, three-way kneading, smearing, spatulate action which actually coats one material with the other, rather than placing components *next* to each other. An intensive, but controlled, mulling action eliminates balling, breaks up agglomerates and provides unparalleled control over the dispersion of moisture, binders, carriers, etc. You get an *intensive,* homogenous mix that *stays* mixed in storage or transit.

How Mulling Pays Its Way

Most important . . . you get a mixer that can quickly *pay for itself* by eliminating reprocessing and remixing, slashing waste and rejects. With a Mix-Muller in the key spot, you can join the hundreds of enlightened processors who have turned problem mixing operations into new profit *opportunities.*

Want Proof?

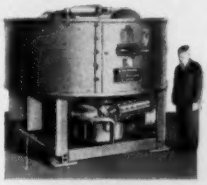
A list of Mix-Muller users will be sent upon request—together with the *Handbook on Mulling* or, write for details on a confidential *mulling* survey of your product . . . conducted under strictest laboratory conditions.


Mix These Two Materials in these amounts . .
And Get This even texture, thorough moisture dispersion
Not This "Hot spots" balling, uneven and wasteful dispersion.

Here's how *controlled mulling* works:

Diagram shows comparative results of blending a minute amount of one material with large amount of another material in (A) MIX-MULLER and (B) conventional mixer. Savings in raw material, reprocessing time and quality of finished product are the outstanding *rewards* of mulling your product.

Simpson Mix-Mullers are available in batch capacities of from ½ to 60 cubic ft. They can be equipped for heating, cooling or chemical interaction during mixing and can be furnished in stainless, alloys or other special materials or linings.



MODEL 3F MIX-MULLER 60 cu. ft. capacity

LABORATORY MODEL ½ - ¾ cu. ft. capacity

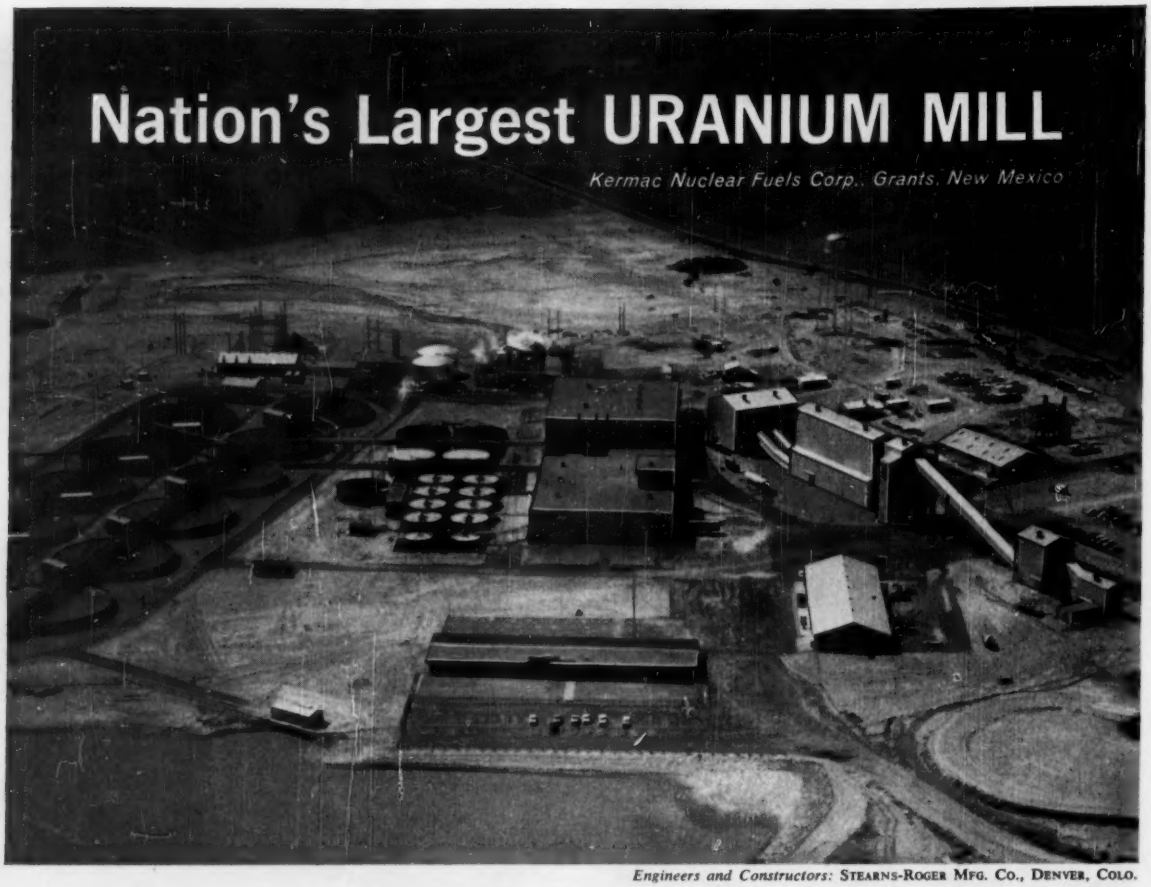
SIMPSON *MIX-MULLER* DIVISION
National Engineering Company
636 Machinery Hall Building • Chicago, Illinois

HOW MULLING gives you controlled dispersion for better blends:

GOING: Mix is wetted, dispersion of coating media begins as lumps form.

GOING: Smearing, *spatulate* action breaks up lumps as mulling action disperses moisture.

GONE: Agglomerates almost gone as blending nears completion. Mix is homogeneous, thorough.



Engineers and Constructors: STEARNS-ROGER MFG. CO., DENVER, COLO.

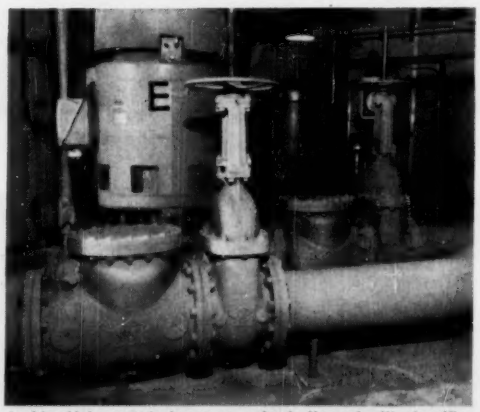
Here, uninterrupted functioning of valves is vital to continuous operation ... so JENKINS VALVES were chosen

This $18,000,000 mill, built in 1958, produces uranium oxide, called yellowcake, from raw uranium ore. Four to five pounds of yellowcake are obtained from a ton of ore by an acid leach, solvent extraction process perfected by Kerr-McGee Oil Industries, Inc. The product is sold under contract to the Atomic Energy Commission.

In the processing, ore and its many derivative components are put through so many washing operations that the mill might be termed the world's biggest "laundry". The valves controlling the use of plant process water are in continuous service.

The chance of valve trouble must be minimized here. It was accomplished by installing JENKINS valves ... chosen on their record of dependable, long-life performance in critical services for almost a century.

YOU PAY NO MORE when you demand these famous valves for your jobs. And, you gain substantial savings through reduced maintenance and replacement of valves. Jenkins Bros. 100 Park Avenue, New York 17.



Jenkins Valves control process water to the rod mill, classifier sections and the acid plant. Also, lines in power house and heating system.

JENKINS
LOOK FOR THE JENKINS DIAMOND
VALVES
JENKINS SINCE 1864
Jenkins Bros

Sold Through Leading Distributors Everywhere

INTEGRATED specialization

PRODUCTION FACILITIES

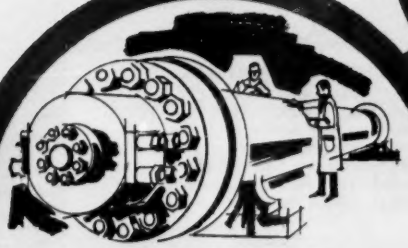
A. O. Smith's production facilities are among the most extensive in the world. The vessel and heat exchanger shops house every advance known to modern technology.

ENGINEERING

MULTI-LAYER construction of high-pressure vessels is just one of A. O. Smith's numerous design innovations. This patented process uses concentric layers of relatively thin steel plate — tightly wrapped and welded around an inner pressure-tight cylinder.

WELDING

A. O. Smith is one of the largest production welders in the world. It has pioneered many new concepts for the welding industry.



QUALITY CONTROL

A. O. Smith's high standards for product excellence are a direct result of its ever-expanding test program. Next spring, for example, the world's most powerful metals' inspection x-ray unit will be installed at the Milwaukee plant. The 8-million-volt linear accelerator will "see" through steel more than a foot thick.

RESEARCH

A. O. Smith carries on extensive research in metallurgy, welding, electrical testing, corrosion resistance — to name only a few areas. The company has also become an outstanding contributor in the atomic field.

building block for A. O. Smith leadership in the manufacturing of pressure vessels and heat exchangers

A. O. Smith will build any type, any size of pressure vessel or heat exchanger — *and build it well!* Employing specialists in every phase of its production program, A. O. Smith can guarantee built-in dependability to a wide range of industries from the petroleum and chemicals to the atomic.

A. O. Smith's dedicated staff of research scientists and engineers will help you analyze your process conditions. It will make recommendations as to the design, material and method of fabrication best suited to your particular needs. **Write today for specific product information.**

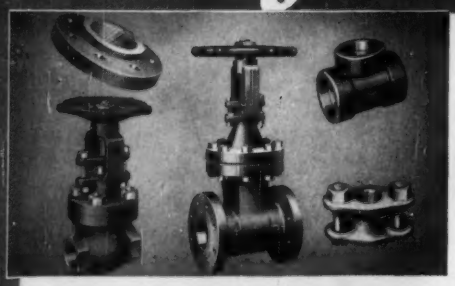
Through research ... *a better way*

A.O.Smith
CORPORATION

ATOMIC AND PROCESS EQUIPMENT DIVISION
MILWAUKEE 1, WISCONSIN

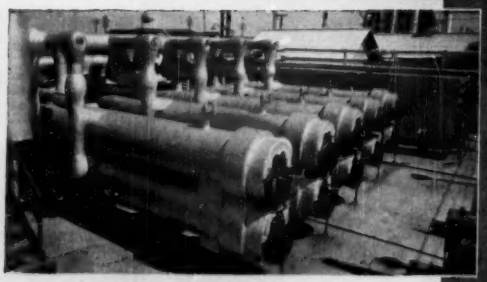
Vogt PRODUCTS

Designed for today's *Tough* service demands



FORGED STEEL VALVES & FITTINGS FOR TOUGHNESS AND TROUBLE-FREE SERVICE

Forged from carbon and alloy steels, Vogt valves, fittings, flanges and unions are built to safely handle liquids and gases at high pressures and temperatures in the modern petroleum refinery and petro-chemical plants. The complete line includes flanged, screwed and socket weld end globe, gate and check valves—ells, tees and crosses—couplings—bushings—plugs—unions—flanges and flange unions—and weld caps.



PROCESS EQUIPMENT FOR EVERY SERVICE

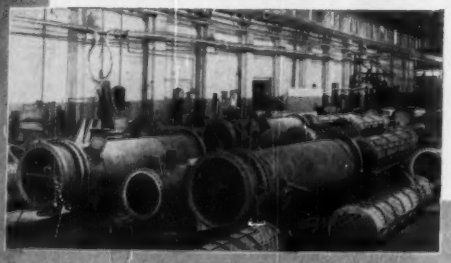
Vogt constructs process equipment in wide variety to all Codes. Stills and towers, oil chillers, crystallizers, heat exchangers, molding machines, etc., serve in the manufacture of oils, greases, 100 octane gasoline, synthetic rubber, chemicals and related products around the world.

MORE REFRIGERATION TONNAGE AT LESS COST

More than 70 years of engineering and manufacturing experience is incorporated in Vogt refrigerating and ice making equipment. Compression Systems and Tube-Ice Machines in a wide range of capacities serve industrial and processing plants and institutions here and abroad.

HIGH EFFICIENCY STEAM GENERATORS

Vogt steam generators are designed to give maximum rating in a minimum of space, with high efficiency and low maintenance expense. Bent tube and straight tube designs are available for solid, liquid or gaseous fuels to meet every power, process or heating requirement.



SPECIAL MATERIALS COMBAT CORROSION AND PRODUCT CONTAMINATION

Our modern shops produce a wide variety of equipment from special metals and alloys to fight corrosion and product discoloration or contamination. Fabrication procedures insure that corrosion resistant properties of welds will match that of the materials used to construct the equipment.

HENRY VOGT MACHINE CO., LOUISVILLE, KY.

SALES OFFICES:
New York, Chicago, Cleveland, Dallas, Camden, N. J.,
St. Louis, Charleston, W. Va., Cincinnati

PRODUCTS FOR REFINERIES, CHEMICAL PLANTS, POWER PLANTS AND PROCESS INDUSTRIES
Write for literature, Dept. 24A-GC

Last month in Kansas City, Chemical Engineering *and Midwest Research Institute sponsored a two-day technical conference to re-emphasize the fundamental importance of chemistry, mathematics and physics in chemical engineering. It called attention to techniques based on these sciences that are beginning to find application in our field. At this conference, ten papers were presented covering The New Tools of engineering, The New Mathematics and The New Chemistry. There were two of these papers in our last issue, two in this and the remaining six will appear in the issues of January 1961.*

Process Kinetics Can Predict Reaction Mechanism

Analysis of the molecular structure of reactants by the reaction rate theory makes it possible to predict the rate determining steps for elementary reactions, accommodation coefficients, thermal conductivity in liquids, liquid structure, liquid viscosity, diffusion coefficients, strain electrometry or ion smelting

HENRY EYRING, *University of Utah*

Ultimate aim of reaction rate theory is to predict the reaction mechanism or the chain of reactions connecting any set of reactants with products on the basis of the molecular structure of the reactant molecules. Such an analysis leads to a rate-determining step for a single reaction or series of such steps for chain reactions. There is a close analogy[1, 2, 3] between matter transport through a chain of reactions and conduction of electricity through a network of conductances connected in series and in parallel. Simple systems involving a single rate-determining step are less common than cases complicated by surface catalysis or other types of side reaction chains.

Elementary Reactions

However complicated a system, the application of chain reaction theory allows us to express the over-all rate in terms of the concentrations and the specific reaction rates for elementary reactions. Absolute reaction rate theory[4] for the specific reaction constant, k', gives well-known expression:

$$k' = H \frac{kT}{h} K^{\ddagger} \qquad (1)$$

where H is transmission coefficient, k is Boltzmann constant, T is absolute temperature, h is Planck's constant and $K^{\ddagger}$ is equilibrum constant. The equilibrium constant $K^{\ddagger}$ is normalized to one quantum state for the reaction coordinate. This means that the length, δ, of the activated complex along the reaction coordinate at the top of the barrier is to be chosen so that:

$$\frac{(2\pi m^{\ddagger} kT)^{1/2}}{h} \delta = 1 \qquad (2)$$

or

$$\delta = \frac{h}{(2\pi m^{\ddagger} kT)^{1/2}} \qquad (3)$$

Consider the familiar type reaction:

$$H_{2(para)} + H = H_{2(ortho)} + H \qquad (4)$$

At the activated state that is linear, the two outer atoms move in phase with respect to the central atom, giving a reduced mass $m^{\ddagger}$ having the value $m^{\ddagger} = (2m_H m_H)/(3m_H) = (2/3)\, m_H$ where m_H is the mass of the hydrogen atom. Solving Eq. (3) for this value of the reduced mass and at 1,000 K., a

reasonable temperature for the homogeneous reaction, gives $\delta = 0.67$ angstroms. Now the de Broglie wave length for this system passing over the barrier with the mean kinetic energy $\frac{1}{2}kT$ is:

$$\lambda = \frac{h}{\sqrt{m^1 kT}} = \sqrt{2\pi}\,\delta = 2.5\delta = 1.7\mathring{A} \qquad (5)$$

In the classical approximation, the length of δ is without significance since it cancels out of the specific rate constant. However, being 2.5 times smaller than the mean de Broglie wave length for all reactions independent of the reduced mass or temperature means that in quantum mechanics we need to examine barrier curvature to estimate barrier leakage.

Wigner's[6] approximate correction for leakage is the factor $[1 + (h|\nu|/24\ kT)]$ where ν is the imaginary frequency corresponding to crossing the barrier along the reaction coordinate. Now, $h\nu$ for the normal vibration of the hydrogen molecule is 12.4 kg.-cal./mole and kT at 1,000 K. is 2 kg.-cal./mole. Thus, if the imaginary frequency across the barrier were equal to the vibration frequency of the reactant hydrogen molecule, the correction factor for leakage would be 1.26. Since the ratio of imaginary barrier frequency to reactant molecule frequency is apt to be much smaller than unity, the correction for leakage is expected to be of the order of a few percent and is ordinarily neglected.

The rate of reaction due to reflection at the barrier deviates from the classical value in the opposite direction by a roughly equal amount. In Chap. 16 of "Quantum Chemistry,"[7] a fairly detailed treatment of barrier leakage and reflection according to quantum mechanics is given, including a discussion of Carl Eckart's[7] exact solution of a one-dimensional barrier. A discussion of transmission and reflection on multi-dimensional surfaces as available at that time is included. It seems preferable to include in the transmission coefficient H the product of all factors necessary to make k' exact. The accommodation coefficient for a molecule striking a surface is of considerable interest and will now be considered.

Accommodation Coefficients

Because the translational energy levels lie so close together for a gas, and even for a liquid, one expects few quantum restrictions on energy transfer between translational degrees of freedom. For this reason, a vapor molecule striking its own liquid surface is expected to stick if it is mono-atomic or freely rotating in the liquid. This is no longer true if the molecule does not rotate freely in the liquid state.

Only those vapor molecules that can change their rotational state adiabatically into acceptable liquid motions may be expected to stick and not re-evaporate. This is because only occasionally is the rotational energy apt to change during the usual collision. Thus, it seems reasonable to expect the probability of sticking, the accommodation coefficient, to equal the ratio of liquid rotational partition function to that of the vapor. This ratio δ of rotational partition functions that Kincaid and Eyring[8] called the free angle ratio satisfies the equation

$$\delta = e^{\Delta S'/R} \qquad (6)$$

Here, $\Delta S'$ is the excess molal entropy of vaporization over that expected from Trouton's rule. This equality between free angle ratio and accommodation coefficient noted by Wylie[9] is a useful rule and is reasonably well explained in a paper by Mortensen and Eyring[10] where calculated and observed values for various liquids are compared.

When an atom strikes a clean solid surface, energy must be transferred from the collisional degree of freedom to vibrational degrees of freedom of the solid if the molecule is to stick. On a dirty surface, colliding atoms may stick by glancing blows with adsorbed molecules that take up energy more readily than the stiffly bonded atoms of the solid.

Thermal Conductivity in Liquids

The number of molecules per square centimeter multiplied by the number of round trips each makes and by the heat carried per strip gives the thermal conductivity. Heat carried per trip depends on the temperature drop between successive layers and the heat capacity that equilibrates during the time of a collision. Such a picture suggests that only translational degrees of freedom should be completely effective since rotational and internal molecular vibrations would not be expected to completely equilibrate in the time available. This is in rough agreement with experiment[8] but more work is required and further comparison must be made with the thermal conductivity of solids.

Since a condensed phase is a good model of a giant molecule, thermal conductivity of liquids and accommodation coefficients yield valuable information for understanding the flow of energy in molecules decomposing unimolecularly. Thus, N. B. Slater's model of negligible transfer of energy between normal modes of an energized molecule about to decompose[11] unimolecularly is not in line with the substantial thermal conductivity of solids.

Mass spectrography is proving to be another valuable tool for studying unimolecular decompositions that presumably proceed by transferring energy[12] between the approximate normal modes, calculated from the theory of small vibrations as well as by synchronizing the phase relations between normal modes in such a way as to exceed the breaking strength of a vulnerable bond.

Significant Liquid Structures

Since the properties of ordinary molecules are important in any discussion of reaction kinetics, an understanding of the thermodynamic properties of liquids is prerequisite to a proper understanding of transport properties or other rate processes in liquids. The thermodynamics of solids can be adequately formulated in terms of a perfect solid lattice. Only the transport properties of solids require that account

be taken of imperfections such as dislocations and vacancies.

In liquids, imperfections are more prevalent and even the thermodynamics requires that proper account be taken of the most prevalent imperfections. A hole of molecular size confers on a molecule that jumps into it gas-like properties; in addition, neighbors of the hole have a positional degeneracy that adds a corresponding increment to the entropy of the solid-like part of the liquid. Now, for each mole of molecules there are $(V - V_s)/V_s$ moles of molecular sized holes. Here V and V_s are a mole of liquid and of solid, respectively.

Such a hole completely ringed by molecules will confer on the particular neighbor jumping into the hole gas-like properties. Since on the average it is incompletely ringed by molecules, we can expect that $(V - V_s)/V$ moles of holes will make $(V_s/V) \times (V - V_s)/V_s$ or $(V - V_s)/V$ moles of gas-like molecules. Here, the factor V_s/V expresses the fraction of occupied sites. The remaining V_s/V moles of molecules remain solid-like.

Thus, one expects for the specific heat C_v *at* constant volume the value:

$$C_V = 6\left(\frac{V_s}{V}\right) + 3\left(\frac{V - V_s}{V}\right)$$

This expectation is in excellent agreement with the observed specific heat of argon.[13] Most simple liquids, we suppose, tend to assume an imperfect hexagonal or cubic close-packed array of molecule and vacancies. The number of moles of molecules that have a vacancy as a neighbor, assuming random distribution, is then 12 $(V_s/V)(V - V_s)/V_s$, which is taken as the number of degeneracies in the solid-like structure. We suppose these can be occupied at an expenditure of strain energy of:

$$\frac{a'}{n_k} = \frac{aE_sV_s}{V - V_s} \qquad (7)$$

These considerations lead to the following partition function f for liquid argon:

$$= \left[\frac{e^{E_s/RT}}{(1-e^{-\theta/T})^3}\left\{1+12\left(\frac{V_s}{V}\right)\left(\frac{V-V_s}{V}\right)e^{-aE_sV_s/(V-V_s)RT}\right\}\right]^{NV_s/V}$$

$$\times\left[\frac{(2\pi mkT)^{3/2}}{h^3}\,\frac{eV}{N}\right]^{(NV-V_s)/V} \qquad (8)$$

Here, E_s is molal energy of sublimation, V_s is molal volume of the solid at melting, θ is characteristic temperature of the solid, R is gas constant, T is absolute temperature, m is mass of the molecule, k is the Boltzmann constant and h is Planck's constant. Thus, every quantity in Eq. (8) is fixed *a priori* except a, which measures the strain energy associated with moving to an alternative solid-like equilibrium position.

In Table I, the quantity $12V_s/V$ is taken as the constant n and chosen to best fit the data. For the random distribution assumed, n should be about 0.9 times 12. If the holes tend to stay apart, n should approach 12. In any case, the observed values of n are satisfactorily close to the expected value.

Since the Helmholtz free energy A has the value:

$$A = -kT \ln \qquad (9)$$

it follows that an explicit expression for f makes it possible to calculate all the thermodynamic properties of a system. These are gathered together in Tables I and II. In Table I, the critical properties were calculated taking a equal to zero. Table II shows that better critical volumes are calculated if the unnecessary approximation a equal to zero is avoided.

Similar correspondence between the theoretically and experimentally obtained thermodynamic properties are obtained for various types of liquids[15, 14] including metals[15] and molten salts.[16] The liquid isotopes of nelium and hydrogen are currently under investigation.

In describing the liquid as having the fraction $(V - V_s)/V$ of gas-like degrees of freedom, with the rest solid-like, it must be realized that these two types of structure are intermingled so intimately that there is no solid-nucleus large enough to nucleate the solid, no gas-like nucleus large enough to nucleate a gas bubble.

Critical properties of rare gases—Table I

	Ne	Ar	Kr	Xe	
n	11	10.80	11.70	12.27	
a	0.00802	0.00534	0.00590	0.005632	
P_m	0.437	0.732	0.7558	0.3986	calc.
	0.417	0.674	0.722	.....	obs.
S_m	3.2442	3.2627	3.456	3.4151	calc.
	3.2587	3.335	3.35	3.40	obs.
V_m	16.427	28.902	33.114	42.303	calc.
	16.15	28.03	34.13	42.68	obs.
T_b	27.13	87.29	119.28	167.5	calc.
	27.26	87.29	119.93	156.1	obs.
S_b	15.679	19.403	19.27	19.431	calc.
	15.81	17.85	17.99	18.29	obs.
P_c	37.65	58.72	69.68	74.89	calc.
	26.8	48.00	54.24	38.2	obs.
T_c	55.41	154.44	208.33	287.8	calc.
	44.47	150.66	210.6	289.8	obs.
V_c	43.48	76.69	88.32	113.52	calc.
	41.74	75.26	.....	113.8	obs.

Critical data for argon—Table II

	Calculated	Observed	%
T_c, °K.	149.7	150.66	−0.637
V_c, ml.	83.68	75.26	11.2
P_c, atm.	52.93	48.00	10.3

P_m Vapor pressure at melting point.
S_m Entropy of melting.
V_m Liquid molal volume at melting.
T_b Boiling temperature.
S_b Entropy of vaporization at boiling.
P_c Critical pressure.
T_c Critical temperature.
V_c Critical volume.

Liquid Viscosity

If we assume that the activation energy at constant volume for the solid-like structure in the liquid is a''/n_λ where a is closely approximated by the a' in Eq. (6), we can calculate the viscosity and self diffusion coefficients over the entire liquid range.

By definition, the viscosity is:

$$\eta = \frac{f}{ds/dt} = \sum_i \frac{X_i f_i}{ds/dt} = \sum_i X_i \eta_i \qquad (10)$$

Here, f, ds/dt and X_i are the stress, rate of strain and the fraction of the area on a shear plane involving the i-th kind of flow unit, respectively. In a pure liquid, we have for the fraction of solid-like structure, $X_s = V_s/V$, and for the fraction of gas-like structure $X_g = (V - V_s)/V$.

Rewriting Eq. (10) for a liquid in accord with our model yields:

$$\eta = \frac{V_s}{V}\,\eta_s + \frac{V - V_s}{V}\,\eta_g \qquad (11)$$

where, η_s *and* η_g are the viscosity of solid-like and gas-like units, respectively. The expression for η_g is taken as the well-known viscosity of the gas. The term involving η_g in Eq. (11) makes only a small contribution to the total viscosity.

Long ago, the formula for the solid-like viscosity η_s corresponding to molecules flowing in a lattice structure was derived.[17] The result is:

$$\eta_s = \frac{kT\lambda_1}{\lambda^2\lambda_2\lambda_3 k'} \qquad (12)$$

Here k is Boltzmann constant, T absolute temperature, k' frequency of jumping in a direction to relieve stress, λ^2 component of mean square distance jumped in the direction to relieve shear stress, λ_1 distance between shear planes, λ_3 lattice distance normal to both λ and λ_1, λ_2 lattice distance parallel to λ.

Since λ^2 is to be averaged over jumps into the various neighboring positions, it has the value $\lambda^2 \cos^2\theta = \lambda^2/3$ where λ is the jump distance, a lattice distance. For the frequency of jumping forward k' we can write:

$$k' = \frac{1}{6}\left(12\,\frac{V_s}{V}\right)\left(\frac{V - V_s}{V_s}\right)\frac{kT}{h}\,(1 - e^{-\Theta/T})e^{-a''E_s V_s/(V - V_s)RT} \qquad (13)$$

This corresponds to the fact that only $\frac{1}{6}$ of all the neighboring positions 12 (V_s/V) $(V - V_s)/V$ are accessible and then only at any activation energy a'' E_s $V_s/(V - V_s)$ and that aside from the reaction coordinate the vibrational degrees of freedom in the normal and activated state cancel out. Now, if the results from Eqs. (13) and (12) are substituted in Eq. (11), using the same values of all parameters that were used in calculating thermodynamic properties, we can calculate the liquid viscosity from the melting point to the critical point almost within experimental error.

Diffusion Coefficients

Einstein[18] related the diffusion coefficient of particles of radius r flowing through a continuum of viscosity η by the equation:

$$D = kT/6\pi r\eta \qquad (14)$$

Sutherland[19] found this became:

$$D = kT/4\pi r\eta \qquad (15)$$

if one considered particles diffusing through a viscous medium of like sized particles. In our laboratory,[20] we obtained:

$$D = kT/\xi\lambda \qquad (16)$$

which is almost identical to Eq. (15), since $\lambda = 2r$ and $\xi = 6$ is the number of nearest neighbors lying in the same plane as the diffusing molecule. This assumes a hexagonal or cubical close-packed liquid. Eq. (16) gives almost exact agreement with experiment for self diffusion and is readily generalized for other types of diffusion. Thermal conductivity is currently under investigation.

Surface Tension

Since Eq. (8) for the partition function applies equally well to gas, liquid or solid state, it should apply to the surface layers of a liquid if proper account is taken of the gradient in the number of neighbors in a direction normal to the surface. This means that only the energy of sublimation E_s need be corrected to the value

$$E_{ss} = E_s = \left(\frac{6}{12}\,\frac{\rho_i}{\rho_i} + \frac{3}{12}\,\frac{\rho_{i+1}}{\rho_i} + \frac{3}{12}\,\frac{\rho_{i-1}}{\rho_i}\right) \qquad (17)$$

Here, ρ_i is the density in the i-th layer for which E_{ss} is being calculated and ρ_{i-1} is the density of the layer just above the i-th layer and in the direction of the vapor; ρ_{i+1} is the density of the layer just below the i-th layer; 6/12 and 3/12 are the fraction of nearest neighbors lying in the layers in question. For the surface layer, we use:

$$\rho_{i-1}/\rho_i = e^{-z} \qquad (18)$$

where:

$$z = \frac{E_s}{2T_c}\left(\frac{T_c - T}{RT}\right)$$

This expression corresponds to the fact that the ratio of densities must be unity at the critical temperature and also that a colliding gas molecule is attracted by the three surface nearest neighbors, whereas in the i-th layer a molecule has about nine nearest neighbors or an excess of 6 out of 12 neighbors. This has been assumed to correspond to an excess binding energy of the i-th layer of $E_s/2$ to sufficient accuracy.

The density of ρ_{i+1} is first estimated as equal to the bulk liquid and a value guessed for ρ_i. The resulting value of E_{ss} is then substituted in Eq. (8) in place of E_s and the molal volume V_i calculated. If calculated V_i agrees with ρ_i, the corresponding excess Gibbs free energy of a square centimeter of the i-th layer is the contribution of this layer to the surface tension. If ρ_i does not correspond to V_i, the estimated ρ_i is modified until agreement has been obtained. The contribution of successive layers to the surface tension can be calculated using a self consistent set of densities.

The surface tension of argon calculated in this way agrees within less than 2% over the whole liquid

range. For methane, the discrepancy between calculated and observed surface tensions reaches 5%. About 90% of the contribution to the surface tension comes from the top layer with almost all of the rest coming from the second layer. It is difficult to avoid the conclusion that our model of a preponderance of holes of molecular size in the liquid is an extremely good approximation.

Ions at Interfaces

In a series of papers on strain electrometry,[21] wire electrodes in solution are strained, giving rise to transient potentials that for an aluminum wire are in excess of one volt. An electrode can be thought of as an electron bank in which electrons are being deposited and withdrawn by various ionic reactions taking place at the electrode.

If the velocity of the i-th electron withdrawing reaction, at zero potential, can be represented by U_i and the i-th electron depositing reaction by U_i', the voltage V at room temperature is given by:

$$V = \frac{0.059}{Z} \frac{\log \Sigma U_i}{\Sigma U_i'} \qquad (19)$$

This equation is true providing all reactions involve ions with the same absolute value Z for the valence. If this is not true for the i-th reaction, U_i should be multiplied by e^{-m} and U_i' by e^{n} where:

$$m = \frac{23{,}060(Z_i - Z)\alpha}{RT}$$

$$n = \frac{23{,}060(Z_i - Z)(1 - \alpha)}{RT}$$

and α equals 0.5 for symmetrically acting barriers.

The study of changes in the nature and purity of the electrodes, composition of the electrolyte and of the atmosphere, and of such things as temperature and stirring, are a rewarding but complicated measure of corrosion and of hydrogen adsorption and absorption. When only one reaction and its inverse is involved, Eq. (18) becomes Nernst's equation. A transient initiated by strain disappears as the surface is reoxidized, terminating the voltage generating reaction.

Smelting Involves Ions

Application of absolute reaction rate theory to smelting[22] reveals that the process involves ions depositing or picking up electrons at the interface of the slag and molten metal. The oxide-ion from the slag combines with carbon from the metal to make carbon monoxide, which then escapes.

Electrons deposited on the metal provide the driving force in the form of an interfacial potential to shuttle sulfide-ions and various metal ions back and forth across the interface in such a way as to reduce the potential. The potential, in effect, changes the activity coefficient of ions at the interface and these ions diffuse in accordance with the activity gradient, which is frequently opposed to the concentration gradient for various ions. It was extremely easy to use reaction-rate theory to clinch King and Ramachandran's suggestion that smelting is an electrolytic process. In fact, it simply reverses the corrosion process under very different conditions.

I hope this brief discussion may at least provide a road map for those who may want to explore certain of these kinetic processes further.

References

1. R. B. Parlin and H. Eyring, "Ion Transport Across Membranes," p. 103, Academic Press, New York (1954).
2. J. C. Giddings and H. Eyring, *J. Phys. Chem.*, **62**, 305 (1958).
3. D. Nachmansohn, "Molecular Biology," see article p. 77 by H. Eyring, Academic Press, New York (1960).
4. S. Glasstone, K. J. Laidler and H. Eyring, "Theory of Rate Processes," McGraw-Hill, New York (1941).
5. E. Wigner, *Zeits. f. physik. Chem.*, **B19**, 203 (1932).
6. H. Eyring, J. Walter and G. E. Kimball, Chap. XVI, "Quantum Chemistry," John Wiley, New York (1944).
7. C. Eckart, *Phys. Rev.*, **35**, 1303 (1930).
8. J. F. Kincaid and H. Eyring, *J. Chem. Phys.*, **6**, 10 (October, 1938).
9. G. Wylie, *Proc. Roy Soc.* (London), **A197**, 383 (1949).
10. E. M. Mortensen and H. Eyring, *J. Phys. Chem.*, **64**, 846 (1960).
11. N. B. Slater, "Theory of Unimolecular Reactions," Cornell Univ. Press, Ithaca, N. Y. (1959).
12. H. M. Rosenstock, M. B. Wallenstein, A. L. Wahrhaftig and H. Eyring, *Proc. Natl. Acad. Sci.*, **38**, 667 (1952).
13. H. Eyring, T. Ree and N. Hirai, *Proc. Natl. Acad. Sci.*, **44**, 7, 683 (1958).
14. E. J. Fuller, T. Ree and H. Eyring, *Proc. Natl. Acad. Sci.*, **45**, 11, 1594 (1959).
15. C. M. Carlson, H. Eyring, T. Ree, *Proc. Natl. Acad. Sci.*, **46**, 5, 649 (1960).
16. C. M. Carlson, H. Eyring and T. Ree, *Proc. Natl. Acad. Sci.*, **46**, 3, 333 (1960).
17. H. Eyring, *J. Chem. Phys.*, **4**, 4, (1936).
18. A. Einstein, *Ann. Physik.*; **77**, 549 (1905).
19. G. B. B. M. Sutherland, *Philos Mag.*, **9**, 781 (1905).
20. H. Eyring, T. Ree, D. M. Grant, R. C. Hirst, *Zeit. f. Elektrochemie*, **64**, 1, 146 (1960).
21. A. G. Funk, J. C. Giddings, C. J. Christensen and H. Eyring, *Proc. Natl. Acad. Sci.*, **43**, 5, 421 (1957); A. G. Funk, J. C. Giddings, C. J. Christensen and H. Eyring, *J. Phys. Chem.*, **61**, 9, 1179 (1957); A. G. Funk, D. N. Chakravarty, H. Eyring and C. J. Christensen, *Zeits. f. Physikalische Chemie Neue Folge*, 15. Bonhoeffer-Gedenkband, Frankfurt am Main (1958); J. C. Giddings, A. G. Funk, C. J. Christensen, H. Eyring, *J. Elec. Soc.*, **106**, 2, (1959).
22. X. de Hemptinne, H. Eyring and T. Ree, "The Electrochemical Theory of Smelting and Related Reactions" (to be published).

Meet the Author

HENRY EYRING *is dean of the graduate school and professor of chemistry at the University of Utah. He has published over 285 papers in scientific and technical journals on rate processes and kinetics and is the co-author of three books in the same fields. He has a B.S., and M.S. from University of Arizona and Ph. D. from University of California and is the recipient of honorary D. Sc. from Utah, Northwestern and Princeton Universities.*

Information Retrieval: What

J. W. PERRY, *University of Arizona*

The booming technology of the twentieth century has produced a geometrically increasing avalanche of scientific literature. To keep abreast, we must develop new, imaginative methods of classifying and indexing this information, and then retrieving it from storage. The new information-retrieval techniques will be cooperative ventures of men and machines. In a given field, information retrieval must be integrated with professional activity in that field. For the CPI, this means close coordination with research and development, with production and sales planning, with management decisions.

"What will it do for me?" is a key question when considering new types of methods and equipment.

There are straightforward, even obvious, relations between progress in chemical engineering and new developments in such fields as inorganic chemistry, process kinetics, computation and systems engineering. Much less evident is the contribution that information retrieval can make. This is due, in part, to the fact that present-day information-retrieval methods are scarcely more than a preliminary stage in the development of much more powerful techniques. These methods, in the foreseeable future, will provide such capabilities that the term "information retrieval" will be far too narrow.

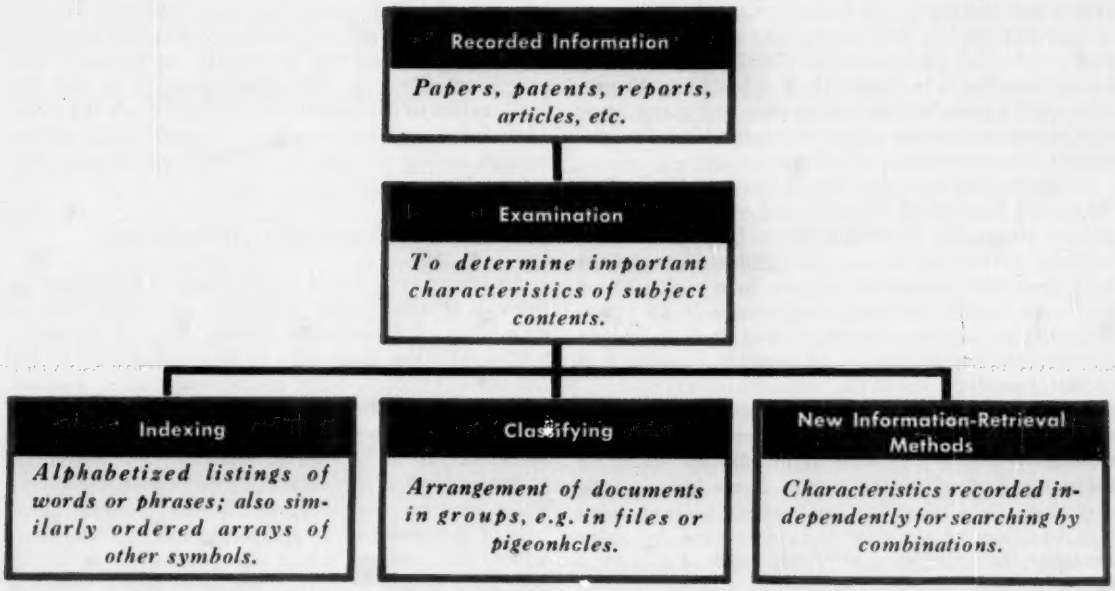
The scope of potential application for present-day information-retrieval methods—and for future related methods—is very broad.[1] In the field of chemical engineering, these methods are new tools to improve professional performance in a wide range of decision areas such as: discerning opportunities for profitable product and process development; planning, conducting and evaluating research and development; planning for production and marketing; solving legal and labor problems.

However, as a general preparatory step, it is usually necessary that large volumes of information be processed for practical operation of information retrieval and related methods. Here we have a contrast with the application of computation methods which, when once worked out, can be applied without further ado to the processing of various streams of numerical data. Furthermore, the design of information-retrieval methods has been almost entirely on an empirical basis and the same has been true of planning their practical application.

Potential as Great as Electronic Computers

Because of—and also in spite of—these factors, it seems certain that information retrieval and related methods will contribute as importantly to decision making as electronic computation has to accounting and to solving complex problems in engineering design. If this potentiality of information retrieval and related methods is to be achieved, we must apply well-established engineering principles to guide both the detailed design of most-advantageous information-retrieval methods and the planning of their application

Will It Do for the Chemical Engineer?


Recorded Information
Papers, patents, reports, articles, etc.
Examination
To determine important characteristics of subject contents.
Indexing
Alphabetized listings of words or phrases; also similarly ordered arrays of other symbols.
Classifying
Arrangement of documents in groups, e.g. in files or pigeonholes.
New Information-Retrieval Methods
Characteristics recorded independently for searching by combinations.

Basic similarities and differences—indexing, classifying and information-retrieval methods—Fig. 1

to practical systems. The procedures and techniques of systems engineering are particularly important in this connection.

Present-day information-retrieval methods and the related more-powerful methods of the immediate future are not only more potent than traditional library methods but also more complex. Optimizing the results produced by the newer methods requires that their application be carefully engineered.

Information retrieval, at least in its present stage of development, is often regarded as a form of indexing and classifying that makes use of automatic and semiautomatic devices to overcome the limitations of alphabetized indexing and of classification methods that operate by establishing arrays of documents, correspondence, books and the like. Certainly, the impetus to develop present-day information-retrieval methods was provided by the observed limitations and inadequacies of the traditional methods in dealing with the ever-expanding volume of increasingly complex information that our industrial civilization generates in every field of professional activity.

Present-day information-retrieval methods resemble traditional indexing and classifying in that documents must be examined to determine the important features of subject contents. Establishing and adjusting policies as to what features are, indeed, important is one of the essential steps in setting up and operating traditional indexing and classifying systems, and the same is true of present-day information-retrieval systems. The latter, however, are distinctive (See Fig. 1) in that the individual characteristics of subject matter are each recorded independently and in such a fashion that selection of the information required can be based on combinations of the independently recorded characteristics.[2]

Sharp Contrast With Traditional Methods

A further sharp contrast with traditional methods of indexing and classifying is the use of mechanical or electronic devices to perform selecting operations. In this way, machine operations replace human effort in scanning indexes. The ability to use any one of an extremely large number of new combinations of characteristics when conducting a search enables the searcher to better align his information requirements with the system than is the case with traditional classi-

fication. The latter is limited, in the combinations of characteristics that can be set up, by the number of compartments or similar subdivisions that can be physically established, e.g., the number of pigeonholes or files for grouping documents.

In traditional library classification, a corresponding limitation arises from the obvious fact that a single copy of a book can be placed in only one position on the shelves of the library stack. This means, of course, that the book can be placed in only one group, unless multiple copies are to be purchased. The costs so incurred would extend beyond the price of multiple copies to include additional classification and handling costs, investment in larger library buildings to provide shelf space for multiple copies and many more subtle expenses in managing and using libraries containing larger numbers of volumes.

Attention has been directed to some of the factors that limit traditional indexing and classifying methods, to stress the point that these factors are of a practical nature. In theory, the number of groupings of a classification system can be increased without limit. In theory, the number of entries in an alphabetized index can be increased without limit, to include entries that correspond to all possible combinations of the characteristics of the subject contents of documents being indexed. Such theoretical possibilities encounter practical limitations—especially costs. In addition to prohibitive costs of indefinitely extending the number of either the entries in an index or the groupings in a classification system, account must also be taken of the cost increase caused by using extremely bulky indexes or highly ramified classification systems.[3]

Mechanical and Electronic Aids

Present-day information-retrieval methods use mechanical and electronics devices to identify which documents contain subject matter characterized by a set of features whose combination need not be established until that combination is of practical interest. The documents so selected constitute, rather obviously, a grouping or class defined in terms of the specially established combination of features. In this way, the use of mechanical and electronic devices has made possible the benefits of a classification system indefinitely expanded to establish groupings of all possible combinations of important features of the subject matter in the documents included. The searching machine establishes a specified grouping of documents at the time it is needed. The ability to do this can be provided at reasonable cost, thanks to modern mechanical and electronic technology.[4]

With searching machines of appropriate design, a very large number of index entries can be subjected to selection operations in a reasonable time and such selection can be designated in combinations not only of the words and phrases of conventional indexes but also in relationships between such words and phrases. These relationships are of two types: those that exist between words and phrases by virtue of their definition (sometimes called analytical relationships) and experimentally observed or similarly established relationships (sometimes called synthetic relationships, in contrast).[5]

To summarize, present-day information-retrieval methods resemble traditional indexing and classifying in that characterizing the subject contents of documents in terms of appropriate features is an essential preparatory step. Recently-developed information-retrieval methods differ by using mechanical and electronic devices for searching operations that are defined in terms of combinations of subject-content characteristics for the individual documents. The searching operation determines whether or not the combination of characteristics that designate the scope of search is included among the characteristics of the subject matter of each document being searched for information.

Correlation of Fragmentary Information

An important area of research and development in methods of information retrieval is extending them to correlation of fragmentary information. Such methods would allow documents to be selected even if the full set of characteristics in the combination, as used at present to define searches, were not found among the subject-matter characteristics of each document being searched. It is, of course, essential that searching operations, when performed in this fashion for correlation purposes, shall not result in selecting large numbers of documents of no pertinent interest. The solution of this problem is best considered after attention has been directed to information-retrieval methods which have already been developed so as to attain optimum advantages.

As noted already, the essential common feature of present-day information-retrieval methods is that they permit a newly established combination of characteristics to designate the scope of a search. Evidently, particular importance attaches both to the combinations and to their component characteristics. Stated more precisely, the most important factors in determining the capabilities of different information retrieval methods are:

1. The range of characteristics (which may or may not include analytic or synthetic relationships or both) that may be recorded to designate important features of the subject contents of documents.

2. The range of combinations of characteristics used to designate the scope of a search.

In considering these fundamental factors, and others that are related to them, care is required to avoid confusion between what might be theoretically possible if unlimited time, effort and money were available to operate a given method, and what can be achieved within the practical limitations of budget and personnel.

A great variety of information-retrieval methods has already been developed whose practical operability has been demonstrated. Previous experience in developing and operating information-retrieval systems provides an extensive background of knowledge to guide the selection or design of methods for a given set of circumstances. At present, there can be no doubt that the design of methods and the formulation of procedures for their operation may be adjusted within wide limits to meet more or less severe requirements under widely different operational circumstances.

Indefinitely Valid System Not Possible

In the past, it has been widely believed that classification systems could be developed to correspond to some inherently present, indefinitely valid order of nature that, once discovered, could be readily formulated. For example, in the field of botany, this philosophical postulate dominated the classical period of the development of the taxonomy of plants. Today, this point of view is being abandoned by many botanists.[a] However, much of this kind of thinking that seeks an absolute solution to broad ranges of problems is still in evidence in development of classification systems, particularly for use in libraries. The practically prohibitive cost of reclassifying large numbers of books by present-day library procedures may be mentioned in this connection. It is, perhaps, inevitable that the philosophy of a single indefinitely valid system should continue to exert undue influence on the minds of those concerned with developing or operating information-retrieval systems. Even when the resources of electronic technology are applied to reclassifying or reformulating the characteristics of the subject contents of documents, the task to be faced is not easy.

The philosophy of a single, indefinitely valid system not only overlooks and denies possibilities for future extension of information-retrieval methods but it also fails to take into account certain additional facts. The more important of these may be stated as follows: practical methods cannot be developed as studies in pure logic divorced from practical considerations. Nor can the performance of information-processing methods, e.g, the production of alphabetized indexes, be regarded as an end in itself. The use of such indexes and their ability to service information requirements are the decisively important factors. Effective planning is impossible without clear understanding of the purposes to be served, and optimum system design requires that such purposes be defined with precision.

In the field of chemistry, work in the library is usually regarded as distinct and different from laboratory experimentation, which usually appears to be much more interesting and professionally satisfying. But the new insights that are the goal of experimental work are unlikely, at the very least, to be attained unless they are planned, conducted and evaluated in the light of previous knowledge, recorded for the most part in the libraries which are readily available to researchers.

Chemical Engineers Should Have the Facts

Chemical engineers are called upon not only to develop new products, processes and equipment; they often must also assume much of the responsibility for planning production and marketing and for related business decisions. Being well-informed as to the facts is the surest safeguard against bad decisions in which wishful thinking and reliance on intuition or hunch may predominate.

Even at their present level of development, information-retrieval methods are no more limited to improvement of conventional library services than digital computers are limited to improvement in accounting procedures. The obvious usefulness of mathematical computation in solving engineering problems has facilitated the application of computing equipment outside the field of accounting. Indeed, the computing requirements of ordnance engineering during World War II stimulated development of the prototype of Univac.

The selection and correlation of information that is, in whole or in part, nonnumerical in character has been, traditionally, much less directly integrated with engineering and industrial production. The establishment of special libraries in many engineering and manufacturing organizations was a long step toward bringing the information resources stored in books, reports, etc., to bear both on problems in research and development and on decisions in production planning, marketing, etc. As long as the range of available tools was limited to conventional indexing and classifying methods, card catalogs, file cabinets and similar manual devices, there were rather definite practical limits to the extent to which library operations could be integrated with laboratory, plant and office operations.

More Powerful Tools to Come

The new tools of information retrieval—and future planning should consider the development of still more powerful tools—may be actuated by electrical signals from a distance. The previous links between operations inside and outside libraries (such as acquiring and lending books and other documents, preparing photostats, making notes in the library, answering questions by telephone) can now be extensively supplemented and extended. Just as it is now possible to link measuring instruments to computers that immediately process and interpret data as experimental or production runs proceed, it is also now possible to link library processing and storing of information directly with generating sources. It is also well within the realm of technical capabilities to provide a direct link between the user of a library and its resources. We should be able to eliminate the kind of barriers that reliance on manual methods within libraries has erected around them.

Will it be practically feasible and economically re-

warding first to supplement the library's manual methods by setting up machine-performed routines to do more and more work in the library, and then to carry through increasingly extensive redefinition of the tasks performed by human personnel in the library? The question has already been, and is now being, answered in the affirmative by the development of new information-retrieval methods—and by their continuing development to provide radically new capabilities.

The practical advantages of the new information-retrieval methods have been repeatedly established in many different practical situations, even though the empirical development of such methods makes it virtually certain that their design and operational procedures could be substantially improved. In the past, however, these developments have received impetus from two sources. One was more or less well-formulated awareness of the limitations of traditional indexing and classifying methods and the other was an appreciation of the benefits from surmounting such limitations.

Break the Bonds of Tradition

The development of new information-retrieval methods in the recent past and the extension of their capabilities in the foreseeable future provide us with powerful tools. The benefits will be determined, of course, by how we use them. If we limit ourselves to providing the same kind of library services as before, then the benefits will be limited to such achievements as reducing the costs of the services and improved promptness in providing them.

Such achievements may attain considerable practical importance, but they are relatively insignificant compared to what can be achieved if our requirements are imaginatively redefined in terms of the new methods' capabilities. Indeed, as has been observed repeatedly, acceptance of what can be accomplished with traditional library methods is the greatest single impediment to truly effective application of the newly developed methodology.

It is not possible in a single paper to outline all the possibilities that have been opened up for imaginative redefinition of services to be provided. The introductory summary of new information-retrieval methods directed attention to their basic capability for conducting searches whose scope is defined by establishing appropriate combinations of the characteristics of the subject contents of documents. It is difficult to explain what this basic capability means in terms of broadening the range of information searches conducted by these methods. It is at least equally difficult to show how this basic capability is extended and generalized when both specific and generic concepts are made available as components in such combinations. It is, however, rather easy to account for such difficulties in explaining the capabilities of the new retrieval methods.

Practically everyone makes use of classifications systems of the traditional types. From childhood, we classify articles of clothing in different drawers or spaces in closets. Tools, nuts and bolts, kitchen utensils, indeed practically every kind of material object must be classified to some degree for convenience in use. Our language provides terminology that classifies by naming, e.g., "acid," "dog," "building," or that characterizes by designating more or less specific properties, e.g., "soluble," "red," "large."

We are accustomed to using such indexes as the telephone directory to acquire needed information by consulting alphabetized lists of names or words. But we are not accustomed to methods that enable us to use a sorting device that inspects various objects to pick out those that display a certain combination of characteristics. The very novelty of this type of selecting makes it difficult to imagine the full scope of its potentialities and of its eventual range of applications.

Must Realize Limitations

On the other hand, it is necessary to take care that the capabilities of the new information methods are realistically evaluated. The ingenuity of salesmen in presenting their wares and the enthusiasm of innovators for their intellectual offspring, especially when coupled with ignorance and wishful thinking concerning the limits of methods and machines, can result in overselling and subsequent disillusionment. Even the most complex electronic machines are limited to performing routine tasks whose complexity may lead to overestimating their capabilities with consequences that can be unpleasant, to say the least. Nor are the new information-retrieval methods a form of magic. If these methods are to make important, even spectacular, contributions to the solution of a research assignment, they must, at the least, undergo thoughtful analysis by a scientist or engineer who makes use of them.

The different capabilities of machines and men must be coordinated so that they fit together and complement each other.

From the point of view of specifying what tasks the machines are to perform, we are confronted by a dilemma. If we do not require enough, we fail to use the machines as effectively as we might. If we require too much, disappointing performance is sure to result, usually coupled with excessive costs.

The importance of the following questions is, perhaps, obvious from the previous discussion.

1. How broad a scope of professional activity should an information system be designed to serve?

2. How do the capabilities of the newer information-retrieval methods enable them to supplement and complement the traditional methods of indexing and classifying?

3. How are policies of information processing to be formulated so that information requirements may be efficiently and economically serviced?

4. How are library and laboratory operations to be integrated?

5. How are we to formulate the requirements that a given information system must meet?

6. How are methods for various operations (e.g., writing of reports or papers, their filing and storing, their abstracting, indexing and coding, their delivery as needed from storage) to be integrated to form a system that will serve the needs of a given organization?

7. How can systems that serve different organizations be interlinked among themselves (with due regard to antitrust hazards) and with systems that provide extensive coverage of current publications (such as the abstracting-indexing services of professional societies or trade associations)?

8. How can the value of the services provided by information systems be estimated by those who are to use them?

9. How can costs of various operations in providing information services (especially those operations mentioned under question 6) be realistically determined?

10. How can future developments in information-retrieval methods—and in related methods for correlating fragmentary information, for developing and testing hypotheses and tentative decisions—be anticipated when designing systems for practical operation in the immediate future?

The diversity and scope of these questions are such that it would obviously be impossible to provide answers within the limitations of this paper. Indeed, each of these questions could provide the topic for a lengthy chapter in a book which could well be entitled "Engineering Principles for Information Systems." Perhaps the best that can be done within the space limits of this paper is to indicate how such a book is now being worked out, with special attention to future development of methods.

As the title of this book indicates, its purpose is to present engineering principles for designing and operating information methods and systems and for coordinating or interlinking systems. The development and presentation of engineering principles in any field demands that ranges of requirements be analyzed in terms of appropriate factors or parameters and similar analysis must be made of methods, systems and circumstances under which they are to operate.

Furthermore, the various kinds of factors must be defined with precision, and mathematical formulas to express their interrelationships must be developed so that the performance characteristics of a method or system can be predicted for design purposes from the factors that characterize a hypothetical design and the circumstances under which it must operate in practice.

Material Dealt With Is Information

These rather obvious considerations leave no doubt that the design of information systems presents engineering problems whose difficulty is greatly enhanced by the fact that the material being dealt with is information. It is not a material at all in the usual sense and hence it is subject to laws distinctly different from those of physics and chemistry.[7] Studies appropriate to extending these laws beyond the scope of transmission of signals exist in various sources—too diverse to review in more than the barest outline. Suffice it to say that the postulates for such laws can be derived from modern philosophical studies on scientific methodology.[8]

Mathematical concepts developed in such fields as Boolean algebra, set theory, algebraic topology and measure theory appear appropriate for developing the necessary general laws from the suggested basic postulates.[9] This approach appears essential to serving the dual purpose of (1) developing engineering principles for optimizing the design and operation of information methods and systems comprising a multiplicity of methods and (2) providing reliable theoretical guidance in discerning and defining possibilities for pioneering development of present and future electronic technology.

Mathematics as a Bridge

The basic laws of chemistry and physics are, at least for the most part, quite distinct from the mathematical formulations with which the chemical engineer works in solving design problems and in specifying procedures for process control. These mathematical formulations, which differ more or less among themselves, depending on the category of problem to be solved, constitute a bridge between scientific theory, on the one hand, and engineering problems, related practical experience and engineering research, on the other. Such mathematical formulations, considered from a somewhat more philosophical point of view, constitute embodiments of the principles of chemical engineering. The development and presentation of analogous mathematical formulations and related principles for the engineering of information systems would be a principal purpose of the new book.

As already noted, there is much material available (particularly in such fields as the philosophy of scientific method, information theory, mathematical analysis of language) for defining postulates and developing basic theory for information methods and systems.[10] On the practical side, there is also a broad background of experience available in the empirical development of information-retrieval methods and related systems.

Attempts of a preliminary nature have been made to define performance characteristics of information-retrieval methods and to relate them to cost factors.[11]

The time has come to revise and to extend these studies and to relate them to test data from operation, especially experimental operation, of methods and systems that differ with regard to their design parameters. This is a particularly interesting and fruitful field for research in systems engineering.[12] The dual purpose of such research, namely, optimizing the design and performance of practical systems and guiding pioneering development of new methods, should be emphasized.

Considering the relationship of scientific method to information retrieval can leave no doubt that the latter, at its present stage of development, is not only a useful tool but also a point of departure for further pioneering in developing still-more-powerful methods.

The incentive to their development may be compared to the situation in a chemical-production unit in which a bottleneck develops in one of a sequence of processes. Success in breaking through one bottleneck is likely to result in another bottleneck becoming decisively important. An analogous situation seems likely to develop in the general area of information production and utilization. Indeed, to a certain extent at least, such a situation already exists, as will be pointed out. For the present moment, however, let us consider what the situation will be if, as present trends indicate, the volume of recorded information continues to expand at a rate corresponding to a compound-interest law.

Traditional Methods Becoming Less Capable

We can expect, of course, that traditional indexing and classifying methods will be even less capable of providing needed reference-library service and, what is more important, practically incapable of servicing certain important ranges of questions. At the same time, present-day information-retrieval methods, even though made more effective by improvements analogous to chemical-process improvement, would, at least with a more or less gradually increasing percentage of questions, confront the inquirer (i.e., the information system's customer) with an embarrassment of riches. More documents containing pertinent information would be selected and supplied to the system's customer than he could find time to read, analyze, understand and use.

Can we work toward the development of methods so that part of the customer's task could be performed by automatic equipment? Obviously, his task would be much less time-consuming and fatiguing if machine operations could relieve him of most of the reading, perhaps a large part of the analyzing and, to some degree (probably rather limited), part of the effort involved in understanding.

Before discussing how such extensions in automatically performed operations might be achieved, it may be well to note that the above outlined flood of information brought about by library and file searching is a special case of a more general situation. This arises ever more frequently as advances in research methods and instrumentation allow more observations per unit time and thus larger volumes of factual information for evaluation and correlation. As far as computational processing of numerical data is concerned, the development and continuing improvement of electronic computers have enabled us to keep abreast, maybe even ahead, of the situation.

Problem of Non-numerical Factors

We are in a far less favorable position with regard to the correlative exploitation of observations in which nonnumerical factors are decisively important. The new information-retrieval methods, as the term retrieval indicates, are effective in recalling nonnumerical information from storage to bring together information pertinent to a given problem or situation. But present-day information-retrieval methods go no further, at most, than providing organized subdivisions of the selected information. They stop short of determining how items of information are interrelated and how such items can be fitted together for making decisions.

The situation is particularly difficult when the information is highly fragmentary and when the absence of a previously well-established picture means that there is no framework of reference to which the individual fragments may be related. This situation arises, for example, when large amounts of factual information accumulate but effective hypotheses for correlation, even if proposed, cannot be tested and verified because of the immense amount of human effort required.

Situations of the type just described are more likely to appear in fields of research in which long-standing problems still await effective strategy for attack (for example, leukemia) or in which a sudden advance in observational technology provides large amounts of observational material (for example, meteorology and present-day observations of clouds and the like made by satellites). It is, perhaps, less obvious that a similar situation may arise in a well-established field, such as botanical classification, when the very principles for generating correlative concepts are subjected to the virtual necessity for revision.

Testing Botanical Correlations

In botany, the concept of species was originally formulated in the eighteenth century by Linnaeus and his contemporaries. The principle—more precisely, the assumption—that species exist in an immutably established fashion was, perhaps, hardly tenable after the introduction of Darwin's principle of evolution with its emphasis on adaptation to environment and survival of the fittest.[13] The pressure on botanists to reconsider whether species really exist and if so in what sense has been greatly intensified in recent years by advances in such fields as cytology, genetics and biochemistry.

Not only is the species concept undergoing the most

critical examination, with its reevaluation and redefinition a probable conclusion, but there is also emerging an awareness that reliance on morphological features for establishing useful definitions of groupings is doubtful wisdom as our understanding of the functioning of organisms and related life processes becomes more diversified.[14]

But then the question arises, "How is the labor of testing possible correlations of immense volumes of data to be performed?" This becomes even more challenging when we take into account not only the fact that the volume of data increases but also that new kinds of data are certain to be generated as new methods of research are worked out.[15]

Enough has been said, perhaps, to make the point that there are incentives of a highly practical, even compelling, nature for pioneering development in new methods of evaluative correlation of factual information.

It is not possible, obviously, to blueprint an innovation prior to its development. It is possible, however, to outline an apparently promising strategy for carrying through such a development.

Men and Machines as a Team

The goal might first be stated as achieving maximum practical advantages in applying computers and related electronic technology to evaluative correlation of information that may be partly or entirely nonnumerical in nature. This definition of the goal is intended to imply a division of labor between men and machines.

Indeed, one of the immediate interim objectives would be to discern and to define various operations for which machine procedures might be worked out. Such definition of operations performed by machine would have, as a counterpart, the definition of new tasks to be performed by people, including both the operators of the new information system and also the people whom it serves.

Thus, a new division of labor between men and machines would be defined, first in a tentative, preliminary manner for evaluative testing, then on an operational basis. The soundness of this strategy has been repeatedly confirmed in developing applications of automatic and semiautomatic devices to the most diverse kinds of intellectual and clerical tasks.

In the pioneering development of new correlating methods as outlined above, it seems likely that guidance can be provided, to some extent, by the development of information-retrieval methods during the past fifteen years.

Approaching Limits of Alphabetizing

Prior to 1945, when a truly historical paper[16] pointed to the need for new information-retrieval methods, alphabetized indexing had been undergoing improvement for many years and it is, perhaps, only a mild exaggeration to say that the limits of this method had been approached. Such perfection of indexing methods seems to have been pursued principally as a sort of literary exercise with little attention to mathematical analysis of the operations involved[17] and, in some cases at least, with insistence that classification (and, by inference, the theory of class definition) has little or nothing to do with good indexing.[18]

Experts in setting up classification systems as practical tools, though aware of the underlying logic of class definition,[19] found it impractical or difficult to surmount the limitations imposed by grouping into pigeonholes, files or linear arrangements, especially of books on library shelves.[20] It can scarcely have been coincidental that the first sharp break with traditional classification was the work of the mathematician, Ranganathan.[21] His use of mathematical concepts for guidance in his pioneering development of "faceted classification" points the way to strategy appropriate to the challenging task of exploiting electronic technology to its limits.

It is historically interesting that the limits of traditional classification were also transcended by hand-sorted punched cards. In this case, the capabilities and design of this simple mechanical device guided the development of a new method for information retrieval. Neither Boolean algebra nor the theory of class definition is mentioned in a classical paper whose historical importance can scarcely be exaggerated.[22]

Card Scanner Applies Boolean Algebra

When the development of information-retrieval methods shifted from applying existing devices to altering, at least, their design, mathematical expressions were necessary for guiding the design of both methods and machines. Over ten years ago, it was evident that extension of mechanized documentation to provide present-day information-retrieval methods required that a way be found to surmount the limitations imposed on coding by the card-operated accounting machines then commercially available.[23] An experimental card-scanning machine was constructed by IBM.[24] Its selecting capabilities could be stated quite concisely, as follows, with the aid of simple Boolean expressions.[25]

"The machine may be directed to accept all cards punched for any one of several criteria. Such a search involving six criteria may be symbolized as $A + B + C + D + E + F$. Alternatively, it might be specified that only cards bearing all six criteria would be accepted and such a search might be represented by $A.B.C.D.E.F$. Combinations may be specified such as $(A + B).(C + D + E).F$. Another possibility is to require that some criterion—or one or more of a group of criteria—shall be absent. Examples of such searches are $(A + B).(C + D + E)—F$ or $(A.B + C.D)—(E + F)$."

These formulas were of essential importance both to the design of the special card-scanning machine and to the wiring of its plugboard preparatory to a search. This machine was essentially limited to selections that could be defined in terms of combinations of index

entries punched one after another on cards or groups of cards.

The simple Boolean formulas also suggested an extension of the capabilities of the card-scanning machine. This suggestion was a generalization. More specifically, it became evident that the Boolean algebra might be formulated as a multiplicity of levels, for which the following symbolism is convenient:

A_0, B_0, C_0, D_0, E_0, etc., individual symbols.

A_1, B_1, C_1, D_1, E_1, etc., symbol combinations, analogous to "syllables" in words.

A_2, B_2, C_2, D_2, E_2, etc., "syllable" combinations analogous to "words."

A_3, B_3, C_3, D_3, E_3, etc., "word" combinations analogous to "phrases."

A_4, B_4, C_4, D_4, E_4, etc., "phrase" combinations analogous to "sentences."

A_5, B_5, C_5, D_5, E_5, etc., "sentence" combinations analogous to "paragraphs."

A_6, B_6, C_6, D_6, E_6, etc., "paragraph" combinations analogous to "messages", etc.

The use of such terms as "syllables," "words," "phrases," etc., is purely descriptive and in no way implies any limitation of a syntactical or grammatical nature. There is, of course, no restriction on the number of levels that may be set up. Furthermore, at any "n"th level, a given combination may be specified in terms of component elements at the "n-1"th level or any one or more lower levels, such as the "j"th, "f"th, "h"th, etc. This may be symbolically illustrated as follows:

1. Logical product, an "n"th level combination may be specified as:

$$A_{n-1} . B_{n-1} . C_{n-1} . D_{n-1}, \text{ etc.}$$

or more generally:

$$A_j . B_g . C_h . D_e, \text{ etc.}$$

2. Logical sum, an "n"th level combination may be specified as:

$$A_{n-1} + B_{n-1} + C_{n-1} + D_{n-1}, \text{ etc.}$$

or more generally:

$$A_g + C_e + D_f + E_j, \text{ etc.}$$

3. Logical difference, an "n"th level combination may be specified as:

$$A_{n-1} - B_{n-1}$$

or more generally:

$$A_h - B_j$$

4. Complex combinations of characteristics may be specified as, for example:

$$(A_{n-1} . B_{n-1} + C_{n-1} . D_{n-1}) + (E_{n-1} . F_{n-1} . G_{n-1})$$
$$(A_{n-1} + B_{n-1}) (C_{n-1} + D_{n-1}) (E_{n-1} + F_{n-1})$$
$$(A_{n-1} . B_{n-1} + C_{n-1} . D_{n-1}) - E_{n-1}$$

or more generally, for example:

$$(A_f . B_g + C_h . D_e) + (E_f . F_h . G_f)$$
$$(A_h + B_h) (C_l + D_h) (E_h + F_f)$$
$$(A_h . B_h + C_l . D_g) - E_f$$

In developing methods to characterize the subject contents of documents and for converting information-searching requirements into machine programs, certain advantages were achieved by extending this Boolean algebra to include those formulations in which sequential order might be specified as exemplified by distinguishing a symbol sequence such as RAT from TAR. Thus, if $< >$ is used for specification of symbol sequence, we may distinguish between two different logical products as exemplified by:

$$< A.B.C. >$$
$$\text{and } < C.A.B. > \text{ etc.}$$

Sequential order may be specified also in terms of more complex formulations, including those that involve a multiplicity of levels. For example:

$$< (A_{n-1} + B_{n-1}) (C_{n-1} + D_{n-1} + E_{n-1}) >$$
$$< (< A_{n-1} . B_{n-1} > + C_{n-1}) (< D_{n-1} - E_{n-1} >) > \text{ etc.}$$

These formulations, based on Boolean algebra, have made it possible to develop methods for encoding information as abstracts so that specific terms, related generic terms and also experimentally observed interactions can be recorded and used as criteria for defining searching operations. The same formulations were used to design a low-cost searching-selector and to specify methods for converting information requests into instructions for wiring the plugboard of the selecting machine.[28]

The role of mathematical formulations in these developments has been presented at length to emphasize the key role of mathematics in pioneering new methods. In the future, more general formulations than those of Boolean algebra appear destined to guide such pioneering.

Boolean One of Many Possible Algebras

From one point of view, Boolean algebra may be regarded as one of many possible algebras that could be used to formulate combinational relationships among the members of sets, especially partially ordered sets.[3] The more general notation of sets is particularly convenient in considering the problem of extending coding systems beyond the identification of documents whose subject contents are characterized by some specified combination of features.

Such extension of capabilities becomes important in correlation of fragmentary information. For example, a given entity (person, organic compound, alloy, etc.) may be described in a multiplicity of documents, each of which provides an incomplete statement concerning a certain set of properties that characterize a given entity. In this way, we may—and in practice, indeed, actually do—encounter situations in which the total file contains enough information to establish that a given

entity has a specified set of characteristics, but with no one document containing enough information to establish that fact.

It is important to emphasize that this type of fragmentary information is only one of several examples that may be cited to illustrate a general case whose description is best accomplished in the language of set theory.

Studies already completed indicate that the automatic identification of individuals can be readily accomplished by automatic correlation of fragmentary statements pertaining to various individuals and one or a few of their characteristics.[17] Such methods might be applicable, for example, in correlating fragmentary information on organic compounds, criminals or botanical organisms.

Application in Taxonomy

Automatic methods of correlating fragmentary information appear likely to be applicable to problems in taxonomy, particularly in defining species and relating them to categories of higher order.

This automatic correlation of fragmentary information could be combined with the searching operations of present-day information-retrieval methods. For example, the file to be searched might consist of more or less fragmentary statements of properties of a large number of plants, identified by designation of species, which could be either generally accepted or tentatively defined.

Automatic correlation procedures could then test and determine whether any one species has been observed to possess a given set of characteristics, which could be quite different from those used to define the species. Thus, the usefulness of a given designation of species could be tested.

Other searches, not involving automatic correlation, could be directed to files that consist of descriptions of individual botanical specimens to select those that have been stated to possess a given set of characteristics that constitute a tentative definition of a species. Since electronic technology makes it possible to perform such searches simultaneously and relatively rapidly, it seems possible to develop methods and equipment for the botanist to investigate, without expenditure of undue effort and time, many alternate possible modes of defining species, genera, etc., to generate useful class concepts in his field.

The investigation of tentatively defined species, as outlined above, appears to correspond, at the present stage of evolution of taxonomy, to the application of one level of Boolean algebra. It seems likely that multilevel Boolean algebra may be of importance in two respects in taxonomy. One is to relate the definition of species with the definition of genera and of other categories of higher order. The other is to suggest that the specification of classes should account for relationships and processes of a dynamic nature and thus come to resemble the theories of physics and chemistry more closely.[18]

Grouping Organic Compounds

Mathematical formulation of such methods to help solve classification problems in botany would permit the methods to be applied directly in grouping organic compounds into classes in accord with combinations of properties of chemical, physical, biological or other nature. Thus, studies in automatic methodology for botanical classification can become highly important in the field of chemistry and its applications, especially biologically directed applications.

The correlation of observations is of direct importance to the definition of concepts, and the formulation of the so-called laws of nature (which is the principal goal of scientific research.) If an improvement of breakthrough magnitude in our ability to correlate information and to develop concepts and theories can be attained, the effectiveness of scientific methodology can be raised to a new level.

The mathematical formulations that are essential to developing new correlating capabilities must be based on philosophical postulates, as already noted. As a consequence, these formulations and the effort required for their development are certain to throw new light on fundamental philosophical problems that relate to the nature of human knowledge and methods for its generation. Consequently, the above-outlined development of methods and equipment for accomplishing correlations can be expected in the long run to exert a considerable effect on the future evolution of the scientific method.

Some fifteen years ago, it was evident that inadequacies in traditional library methods had created a bottleneck situation in making use of recorded factual information and that, in the future, this situation was certain to increase. This bottleneck and its elimination become increasingly important to scientific research and technical development as advances in these fields expand our range of knowledge still further.

Increased Awareness of Bottleneck

During the past fifteen years, awareness of the importance of this bottleneck has provided impetus for developing a variety of information-retrieval methods. These, though differing in many features of an engineering nature, all apply the principle of independently recording characteristics of subject contents of documents to enable their selection by designating characteristic combinations established immediately prior to conducting the selection with the aid of mechanical or electronic equipment.

The time has now come to formulate engineering principles for optimizing the design and operation both of information methods (old as well as new) and of systems that comprise a multiplicity of such methods. By basing the development of these principles on fundamental postulates from the modern philosophy of scientific method, new theoretical insights into the fundamentals of developing, testing, confirming, denying, reformulating and applying con-

cepts, hypotheses and theories can be attained. Such insights, when expressed with the aid of appropriately chosen mathematical concepts, can serve as guides in the pioneering development of information methods and systems whose capabilities would place them outside the realm of present-day methods.

The ultimate goal is to ensure that scientific research and technical development, instead of being overwhelmed by factual observations, attain new levels of effectiveness as our abilities to observe expand.

References

1. For a general review of the development of information-retrieval methods during the past 15 years, see: Bello, F. "How to Cope with Information," *Fortune*, **62**, No. 3, 162-7, 180, 182, 187, 189, 192 (1960). For books whose individual chapters present descriptions of information retrieval methods developed to apply automatic and semiautomatic devices in various practical situations, see: Casey, R. S., Perry, J. W. (editors), "Punched Cards. Their Applications to Science and Industry," Reinhold, New York, 1951; Casey, R. S., Perry, J. W., Berry, M. D., Kent, A. (editors), 2nd ed., 1958. Peakes, G. L., Kent, A., Perry, J. W. (editors). "Progress Report in Chemical Literature Retrieval," Interscience Publishers, New York, 1957; Shera, J. H., Kent, A., Perry, J. W. (editors), "Information Systems in Documentation," Interscience Publishers, New York, 1957. For a recent general review of information-retrieval methods with respect to using the chemical literature, see: Perry, J. W., "Chemical Coding" in "Encyclopedia of Chemical Technology," 2nd Supplement, 193-221, Interscience Publishers, New York, 1960.

2. For a careful analysis and detailed presentation of relationships between traditional indexing and classifying, on the one hand, and recently developed information-retrieval methods, on the other, see: Vickery, B. C., "Classification and Indexing in Science," 2nd ed., Butterworths Scientific Publications, London, 1959.

3. For a preliminary study of costs and their relationships to design parameters of systems for indexing, classifying and coding for retrieval by various mechanical and electronic devices, see: Perry, J. W., Kent, A., "Documentation and Information Retrieval." Interscience Publishers, New York, 1957.

4. For a detailed description of methods for encoding abstracts, of the design of circuits for a prototype searching selector and of the conversion of questions to be searched into instructions for wiring the control panels of the selector, see: Perry, J. W., Kent, A., "Tools for Machine Literature Searching," Interscience Publishers, New York, 1958.

5. See, in this connection, Chapter XI, in Perry, J. W., Kent, A., Berry, M. M., "Machine Literature Searching," Interscience Publishers, New York, 1956.

6. See, for example: Davidson, J. F., "A Dephlogisticated Species Concept," *Madroño*, **12**, No. 8, 246-251 (1954); Camp, W. H., "Biosystemy," *Brittonia* **7**, No. 3, 113-127 (1951).

7. See, for example: Khinchin, A. I., "Mathematical Foundations of Information Theory," Dover Publications, New York, 1957; Herdan, G., "Language as Choice and Chance," Nordhoff, Groeningen, 1956; Cherry, C., "On Human Communication," Wiley, New York, 1957.

8. For discussion of philosophical principles of scientific method, see, for example: Margenau, H., "The Nature of Physical Reality," McGraw-Hill, New York, 1950.

9. For preliminary studies along these lines, see: Perry, J. W. and Goffman, W., "Mathematical Formulations of Basic Procedures in Documentation;" "General Structure of Messages." Papers presented at a seminar on "Theory of Documentation and Strategy of Searching" at Western Reserve U., Cleveland, April 12-13, 1960.

10. For an historical introduction to the modern philosophy of scientific method, see: Reichenbach, H., "The Rise of Scientific Philosophy," U. of Calif. Press, Berkeley and Los Angeles, 1951. In addition to reference 8, attention might also be directed to: Cohen, M. R. and Nagel, E., "An Introduction to Logic and Scientific Method," Harcourt, Brace, New York, 1934; Bridgman, P. W., "The Nature of Some of Our Physical Concepts," Philosophical Library, New York, 1952.

11. For a review of preliminary attempts at defining such factors, see: Vickery (Ref. 2), pp. 140-114.

12. Wymere, A. W., "New Developments in Numerical Analysis," presented at IBM Seminar for Directors of University Computing Centers, Endicott, N. Y., July 21, 1960.

13. Burma, B. H., "Reality, Existence and Classification. A Discussion of the Species Problem," *Madroño*, **12**, No. 7, 193-209 (1954).

14. Harrison, J. H., "New concepts in Flowering Plant Taxonomy," Harvard University Press, 1956.

15. Private conversations: Miller, J. N., Dept. of Zoology, Ohio State U.; Russell, N. H., Dept. of Botany, Arizona State U.

16. Bush, V., "As We May Think," *Atlantic Monthly*, **176**, 101-8 (July 1945).

17. See, for example, papers on indexing and subject headings in: Tauber, M. F., "The Subject Analysis of Library Materials," School of Library Science, Columbia University, New York, 1953.

18. Crane, E. J., Bernier, C. L., "Indexing and Index Searching," Chapter 24 in Casey, R. S., Perry, J. W., Berry, M. M. and Kent, A. (editors) "Punched Cards. Their Application to Science Industry." 2nd ed., Reinhold, New York, 1958.

19. Bailey, M. F., "A History of the Classification of Patents," *J. Patent Office Soc.*, **28**, 463, 537 (1946); "Classification of Patents," 2nd rev., U. S. Patent Office, Washington, D. C., 1946. For a report that emphasizes the inadequacies of traditional classifications from the point of view of costs of examining patent applications, see: Bush, V., et al, "Report to the Secretary of Commerce by the Committee on Applications of Machines to Patent Office Problems," Dept. of Commerce, Washington, D. C., Dec. 22, 1954.

20. See, for example, papers on classification in: Tauber, M. F., (Ref. 17). The paper by Shera, pp. 29-42, presents an exceptionally penetrating critique of conventional classification methods.

21. For an evaluation of Ranganathan's pioneering contributions and bibliography, see: Vickery (Ref. 2).

22. Cox, G. C., Bailey, C. F., Casey, R. S., "Punch Cards for a Chemical Bibliography," *Chem. & Eng. News*, **23**, 1623-6 (1945).

23. Perry, J. W., "The ACS Punched-Card Committee. An Interim Report," *Chem. & Eng. News*, **27**, 754-7 (1949); **28**, 3789 (1950); **29**, 4498 (1951).

24. Staff report. "Machine Techniques for Information Selection," *Chem. & Eng. News*, **30**, 2781, 2806-10 (1952).

25. Quoted from: Perry, J. W., Casey, R. S., "Mechanized Searching," in "Encyclopedia of Chemical Technology," vol. 8, pp. 449-467, Interscience Publishers, New York, 1952.

26. Perry, J. W., Kent, A., "Tools for Machine Literature Searching," Interscience Publishers, New York, 1958.

27. Perry, J. W., "Identification by Automatic Correlation of Fragmentary Information." Paper in preparation. For a preliminary discussion of this problem see: Chapter XIV in Perry, J. W., Kent, A., Berry, M. M., "Machine Literature Searching," Interscience Publishers, New York, 1956.

About the Author

J. W. PERRY *trained as a chemical engineer at North Carolina State and at M.I.T. His main interests have been synthetic detergents, scientific Russian, military propellants, documentation methods and nonumerical applications of computers.*

After wartime research on explosives at Aberdeen Proving Ground, Md., he started work on more-efficient library and literature searching at M.I.T. More recently, as Director of the Center for Documentation and Communication Research, Western Reserve U., he designed equipment and methods for machine searching of encoded abstracts. In Sept. 1960, he joined the College of Engineering faculty, U. of Ariz., to carry on his pioneering work.

Dr. Perry is past chairman and an organizer of the Div. of Chemical Literature of the ACS., and a past president of the American Documentation Inst. He is a recent Honorary Fellow of the AIC. He is a member of numerous other societies, including the Chemists Club of N. Y.

H_2SO_4:

Old Dog, New Tricks

D. B. BURKHARDT

Von Bree, Inc., Newark, Del.

A potential cost-cutting area frequently overlooked in the chemical process industries is that of the basic chemical processes used to supply raw materials. One such operation presently being studied for major process improvement and higher profitability is the contact-type sulfuric-acid unit. This article suggests several improvements that appear to be both feasible and economical but require further investigation. The advantages are greatest for future acid units but some changes can be applied to existing units.

In this process, solid brimstone is melted and filtered prior to combustion with moisture-free air, which produces gas containing 8-10% SO_2. This hot gas is cooled to about 430 C. in steam-generating waste-heat boilers before entering the fixed-bed catalytic converter where the SO_2 is oxidized to SO_3. Packed hot-gas filters are sometimes employed before the converter to prevent dust accumulation—and hence increased resistance—in the vanadium catalyst beds. Generated steam is used to melt the brimstone and drive the process air blower. Large quantities of excess steam are produced, which are usually consumed by other steam users at the site. Exhaust gas containing unconverted SO_2 is vented to the atmosphere. Present SO_2-SO_3 conversion is about 94-95% at high production rates.

A review of design changes made during the last ten years reveals that a plateau has been reached in both process and design improvements. Because operating pressure is only a few psig., the large gas volumes handled have resulted in bulky, massive, overdesigned equipment. High gas temperatures and hot acid conditions require special brick linings for the large components. Adiabatic conversion in catalyst beds means that great amounts of catalyst must be employed. Steam generation involves rather expensive boilers, superheaters, economizers and auxiliary equipment. These limitations are well known to people active in the sulfuric-acid business—they are tolerated simply because funds for research investigations have not been allocated for study of alternate methods. Table I gives a breakdown of the major process steps, showing the percentage of unit investment associated with each step. Also shown are estimates of the potential reduction in investment.

What Are the Ideal Conditions?

Before considering improvement, we must review not only existing design limitations but also the changes needed to approach ideality for each process step. Ideal conditions appear to be as follows:

- Brimstone sulfur should be available in the molten form and free from noncombustible material.
- Process gas should be dry and contain the maximum SO_2 consistent with a suitable O_2/SO_2 ratio.
- Energy from combustion should supply power to the process blower directly; excess energy should be used at the same time or converted to electrical energy.
- Gas leaving the combustion step should be at the proper temperature for entering the converter.
- The hot-gas filter should remove dust completely without increasing gas flow resistance appreciably.
- The converter should permit the exothermic reaction to proceed isothermally at the maximum rate. Catalyst should have the lowest possible ignition temperature to provide maximum driving force toward thermodynamic equilibrium.
- The absorption system should be designed for complete removal of SO_3 in relatively small, lightweight equipment.
- Exhaust gases should be minimum in volume and should not contain enough SO_2 to cause atmospheric pollution.
- Instrumentation should be designed to control raw-material addition, gas-flow rates, composition, temperature, pressure, converter reaction rates and functioning of the absorption system.
- The process and the equipment must be chosen to (a) provide safe, dependable, easy operation as well as minimum maintenance; and (b) be capable of producing varying acid quantities at maximum return on the minimum capital investment.

Some Ideas Toward Reaching These Ideals

Several ideas that have a good potential for financial gain are offered in the following paragraphs:

Potential reduction in investment—Table I

Item	Percent of Unit Investment*	Potential Reduction, %
Sulfur melting and storage	6.0	30
Blower and drive	6.0	20
Dry-tower facilities	12.0	20
Combustion chamber	5.0	50
Boiler and steam system	17.0	40
Hot-gas filter	3.0	50
Converter facilities	31.0	30
Absorption system	14.0	20
General facilities	16.0	—

To the reader—Have you found new tricks for another old dog? In other words, we are interested in more articles of this nature, proposing innovations in basic tonnage-chemical processes. If you have any ideas, please contact Practice Editor, Chemical Engineering, *330 West 42nd St., New York 36, N. Y.*

To solve the brimstone problem, molten material that is very low in ash and insoluble carbon content could be obtained from sulfur suppliers. Techniques for maintaining the molten state over long distances are now well developed.

To improve the process oxidant, complete replacement of air with gaseous oxygen is a logical change. The technical feasibility of using oxygen has been demonstrated by Consolidated Mining and Smelting Co. of Canada, Ltd., at Trail, B.C.[1] Cominco's recycle method can increase converter productivity 5-6 times while achieving nearly 100% conversion efficiency. Atmospheric pollution is minimized because only small amounts of inert gases must be purged, and SO_2 is readily recovered from the purge stream.

To be economically attractive, oxygen must be available at relatively low cost. Present-day air-liquefaction units can produce oxygen at low price.

Power Recovery From Sulfur Combustion

An intriguing possibility is a scheme whereby sulfur would be burnt with either air or oxygen at moderate pressure in very small chambers, followed by passage of the hot gas through a gas turbine for power recovery. A common drive shaft would connect the oxidant-gas compressor and the turbine, so that compression power could be supplied directly. The excess power available could provide part of the power needed for air liquefaction directly, or be converted to electrical energy.

The SO_2 gas leaving the turbine could be available at the correct temperature for entering the converter, and at nearly atmospheric pressure. Between compression and combustion, the gas could be used for cooling the converter heat-removal system.

The major obstacle in adopting this proposal has been the lack of gas-turbine construction materials for high temperature, high SO_2 content, oxidizing atmosphere and moderate pressure.

Elimination of noncombustible material in the molten sulfur would greatly facilitate the function of present hot-gas filters. To achieve complete protection of catalyst beds from dust deposition, it appears necessary to replace the friable, crushed firebrick now commonly used as the filter medium. Felted batting or woven bags of refractory material should be successful filter media. Porous ceramic or metallic tubes could also be successful.

The major incentive for better dust filtration lies in making it unnecessary to disturb the catalyst beds for dust removal. Costs of periodic cleaning and of catalyst screening loss could therefore be eliminated.

Improving Catalytic-Reactor Design

A unique concept having an excellent chance of attaining maximum reaction rate with minimum catalyst amounts was developed by D. M. Hurt.[2] In Hurt's arrangement, single-layer beds of catalyst pellets are supported on a screen that is mounted between two plates. SO_2 gas is preheated during passage along the other side of the plates prior to its passage over the catalyst pellets. The heat of reaction is transferred from the pellets to the separation plates and thence to the SO_2 gas, mainly by radiant heat transfer. Conversion is, therefore, carried out nearly isothermally with small catalyst quantities in simple design sections, which can be stacked for compactness.

Simpler, more effective design of converter components would be possible if adequate reaction-rate data were available. Considerable effort is needed to develop the kinetic information to determine conditions for optimum conversion with vanadium catalysts. Modern computer techniques would be invaluable.

Reduction in weight and diameter of packed towers used for air drying and SO_3 absorption would result in appreciable reduction in investment. Brick linings can be replaced by new perfluorocarbon materials, which are now available in film form and can be bonded to steel plate without cement. These films are impervious to acid and can be fused together by controlled heating. Further reduction in weight can be attained by replacing the present quartz pebbles or ceramic rings with suitable fluorocarbon shapes, which would have much higher flooding points.

Present tower performances show that the packed towers are over-designed by 2-3 times the normal production rate. Such caution is due to the lack of information on flooding with present packings.

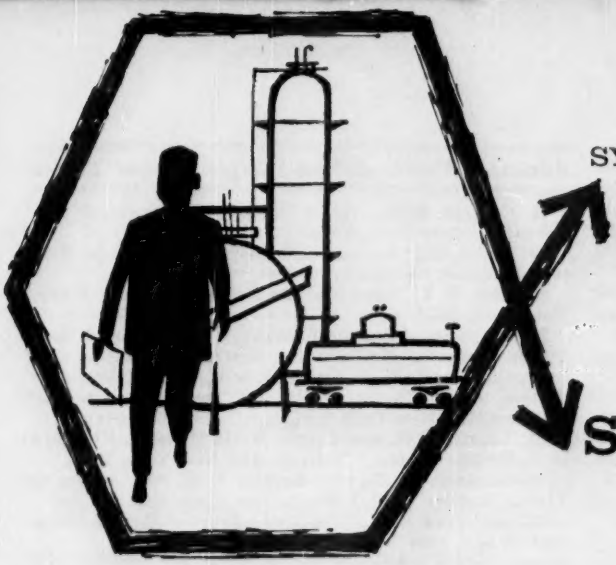
As shown by the foregoing remarks, more knowledge is needed for the basic operation of contact sulfuric-acid plants. The economic incentive for the research required is a potential reduction of 20-25% in capital investment for units using atmospheric air and a five or sixfold increase in production per dollar of investment for units designed to use oxygen instead of air as the oxidant.

References

1. Snowball, A. F., *Canadian Chem. and Proc. Ind.*, 13, No. 12, 1,110-1,114, Dec., 1957.
2. U. S. Pat. 2,246,684, June 24, 1941.
3. Vendor sources.

Meet the Author

D. B. BURKHARDT *is president of Von Bree, Inc. Previout experience includes 12 years with Monsanto and 6 years with Du Pont as consultant on mineral acids. Burkhardt is a member of AIChE and the Electrochemical Soc. and is a registered P.E.*



SYSTEMS ENGINEERING, PART 11

Systems Literature

THEODORE J. WILLIAMS, *Monsanto Chemical Co.*

Many readers of this series,* whether or not involved directly in the fields of systems engineering or process control, may wish to study these fields further. We present here a bibliography of important books and magazine articles that can add greatly in such a study.

Among the elementary textbooks, that of Tucker and Wills[8] is especially recommended to plant engineers. Among the basic servomechanism texts, the books of Chestnut and Mayer[9] are classic; those of Murphy[11] and Smith[12] are also highly recommended. Among the advanced texts, that of Truxal[16] is the one most often found on the control engineer's reference shelf.

As we have brought out in previous parts of this series, analog computers are an indispensable part of control systems investigations. Among the texts on this subject, that by Johnson[88] is highly recommended for those who do not have an electrical engineering background.

The bound symposia volumes listed[20-26] contain many important articles on process dynamics and control.

Several important articles on process dynamics have appeared in German and other non-English periodicals, particularly in *Regelungstechnik* and in *Chemie Ingenieur Technik*. Not included here, these may be gleaned from the author's annual reviews, which are published in *Industrial and Engineering Chemistry*.

Holzbock's descriptive volume on instrumentation[48] is an excellent source of basic information on process control-loop components. Considine's handbook[49] is quite complete and authoritative. The handbook edited by Carroll[45] is the only one available for servicing of instruments. The electronics circuit handbooks of Cockrell[40] and of Markus and Zeluff[83] are worthy of study and frequent reference.

In addition to the 51 books recommended here, 193 magazine articles and technical papers have been classified according to area of interest.

Most problems associated with the control of chemical processes are encountered in distillation, heat exchange, reaction and fluid flow. To the articles listed here may be added the review papers on distillation control by Archer and Rothfus,[62] on heat exchange by Williams and Morris[96] and on reactor dynamics by Lapidus.[107]

Although process control theory has been relatively briefly treated in this series, several other series on basic theory have appeared. Of these, the ones by Burrell,[121] Johnson,[126, 127] Naslin[130] and Williams and associates[131] are considered especially worthy.

A major part of the mathematics of process dynamics is for solutions of families of nonlinear ordinary differential equations. A study of this field, therefore, is important to the process control engineer. The article by Stout[107] and the series by Stout and Kockenberger[108] and by Gibson[124] are important introductions meriting careful study.

The resume by Higgins[102] is a superb bibliographical review of the field of nonlinear control system theory. Much of the theory of nonlinear control systems is discussed in the book by Truxal,[16] too.

There are three major methods of experimental testing of process control systems: the frequency-response method as discussed by Aikman[103] and in the book edited by Oldenburger[20]; the pulse-testing method as described by Lees and Hougen[81]; auto and cross correlations of responses of a system to random inputs as discussed by Goodman,[140] Goodman and Reswick[141] and Reswick.[169]

In the area of process analysis instrumentation, a series of tutorial articles edited by Karp[189] and written by a group of experts[186, 189-191, 203, 207] is especially valuable. A monthly department in *Industrial and Engineering Chemistry*[188, 197, 205, 209] is also important in this area.

Computer control, so popular now and potentially so important to chemical process control, is discussed in the articles chosen, both from the aspects of theory and of applications. The papers by James and Boksenbaum,[214] Laspe,[215] Phister and Grabbe[221] and Stout

* Based on the 1959 Schoch Lecture at the University of Texas, the series has appeared in *Chemical Engineering*, Feb. 8, 1960, pp. 121-16; Mar. 7, pp. 131-6; Apr. 4, pp. 139-44; May 2, pp. 121-6; May 30, pp. 97-102; June 27, pp. 113-118; July 25, pp. 119-124; Aug. 22, pp. 127-132; Oct. 17, pp. 181-186; Nov. 14, pp. 227-232.

and Laspe[209] describe the potentialities of the field. Freilich[213] discusses, in a comprehensive paper, the status of the field as of 1959.

The papers by Eckman and Lefkowitz[211, 216] present a thorough treatment of one of the first process applications of computer control. Two early industrial installations are discussed by Madigan[217] and Eisenhardt and Williams.[212]

Finally, the area of control hardware is well covered by the comprehensive components guide of Olive and Danatos.[220] The series by Beard[204] is also especially informative.

Books on Process Control

Process Control Theory Textbooks

(Elementary)

1. Holzbock, W. G., "Automatic Control: Principles and Practice," Reinhold, New York, 1958.
2. Tucker, G. K., and Wills, G. M., "A Simplified Technique of Control Systems Engineering," Minneapolis-Honeywell Regulator Co., Philadelphia, 1958.
3. Young, A. J., "An Introduction to Process Control System Design," Longmans, Green Co., New York, 1955.

(Basic)

4. Caldwell, W. I., Coon, G. A., and Zoss, L. M., "Frequency Response for Process Control," McGraw-Hill, New York, 1959.
5. Ceaglske, N. H., "Automatic Process Control for Chemical Engineers," Wiley, New York, 1956.
6. Eckman, D. P., "Automatic Process Control," Wiley, New York, 1958.

(Advanced)

7. Campbell, D. P., "Process Dynamics," Wiley, New York, 1958.

*General Control Theory (Servomechanism)**

(Basic)

8. Chestnut, H., and Mayer, R. W., "Servomechanisms and Regulating Systems Design," Wiley, New York, Vol. 1, 2nd. Ed., 1959; Vol. 2, 1955.
9. D'Azzo, J. J., and Houpis, C. H., "Theory of Feedback Control Systems," McGraw-Hill, New York, 1960.
10. Evans, W. R., "Control System Dynamics," McGraw-Hill, New York, 1954.
11. Murphy, G. J., "Basic Automatic Control," Van Nostrand, Princeton, 1957.
12. Smith, O. J. M., "Feedback Control Systems," McGraw-Hill, New York, 1958.
13. Thaler, G. J., "Elements of Servomechanism Theory," McGraw-Hill, New York, 1955.

(Advanced & Handbook)

14. Draper, C. S., McKay, W., and Lees, S., "Instrument Engineering," McGraw-Hill, New York, Vol. 1 (Fundamentals), 1952; Vol. 2 (Mathematics), 1953; Vol. 3 (Pt. 1, Measurement Systems), 1955.
15. Grabbe, E. M., Ramo, S., and Wooldridge, D. E., (Editors), "Handbook of Automation, Computation and Control," Wiley, New York, Vol. 1 (Control Fundamentals), 1958; Vol. 2 (Computers and Data Processing), 1959; Vol. 3; (Systems and Components), in press.
16. Truxal, J. G., "Control System Synthesis," McGraw-Hill, New York, 1955.
17. Truxal, J. G., (Editor), "Control Engineers Handbook," McGraw-Hill, New York, 1958.

* Most have an electrical engineering viewpoint.

Advanced Textbooks on Specific Control Topics*

18. Cosgriff, R. L., "Nonlinear Control Systems," McGraw-Hill, New York, 1958.
19. Ku, Y. H., "Analysis and Control of Nonlinear Systems," Ronald, New York, 1958.
20. Jury, E. I., "Sampled-Data Control Systems," Wiley, New York, 1958.
21. Ragazzini, J. R., and Franklin, G. F., "Sampled-Data Control Systems," McGraw-Hill, New York, 1958.
22. Davenport, W. B., Jr., and Root, W. L., "An Introduction to the Theory of Random Signals and Noise," McGraw-Hill, New York, 1958.
23. Laning, J. H., and Batten, R. H., "Random Processes in Automatic Control," McGraw-Hill, New York, 1956.
24. Gardner, M. F., and Barnes, J. L., "Transients in Linear Systems," Vol. 1, Wiley, New York, 1946.
25. Guillemin, E. A., "The Mathematics of Circuit Analysis," Wiley, New York, 1949.

Application of Computers to Control Problems

26. Johnson, C. L., "Analog Computer Techniques," McGraw-Hill, New York, 1956.
27. Karplus, W. G., "Analog Simulation," McGraw-Hill, New York, 1958.
28. Korn, G. A., and Korn, T. M., "Electronic Analog Computers," 2nd. Ed., McGraw-Hill, New York, 1958.
29. Soroka, W. W., "Analog Methods in Computation and Simulation," McGraw-Hill, New York, 1954.
30. Gottlieb, C. C., and Hume, J. N. P., "High Speed Data Processing," McGraw-Hill, New York, 1960.
31. Stibitz, G. R., and Larribee, J. A., "Mathematics and Computers," McGraw-Hill, New York, 1956 (Digital)
32. Wilkes, M. V., "Automatic Digital Computers," Wiley, New York, 1956.

Important Symposia Volumes

33. Oldenburger, R., (Editor), "Frequency Response," Macmillan, New York, 1956.
34. Society of Instrument Technology, "Automatic Measurement of Quality in Process Plants," Butterworth, London, 1958.
35. Society of Instrument Technology, "Plant and Process Dynamic Characteristics," Butterworth, London, 1957.
36. Tustin, A., (Editor), "Automatic and Manual Control," Butterworth, London, 1952.

Measurement & Control of Process Variables

37. American Institute of Physics, "Temperature: Its Measurement and Control in Science and Industry," Reinhold, New York, Vol. 1, 1941; Vol. 2, 1955.
38. Chaplin, A. L., "Application of Industrial pH Controls," Instruments Publishing Co., Pittsburgh, 1950.
39. Coxon, W. F., "Flow Measurement and Control," Macmillan, New York, 1959.
40. Coxon, W. F., "pH Measurement and Control," Macmillan, New York, 1960.
41. Coxon, W. F., "Temperature Measurement and Control," Macmillan, New York, 1960.
42. Ewing, G. W., "Instrumental Methods of Chemical Analysis," McGraw-Hill, New York, 1954.
43. Jones, E. B., "Instrument Technology, Vol. 1, Measurement of Pressure, Level, Flow and Temperature," Butterworth, London, 1953.
44. Spink, L. K., "Principles and Practice of Flow Meter Engineering," 8th. Ed., Foxboro Co., Foxboro, Mass., 1956.

Control Components

45. Carroll, G. C., "Industrial Instrument Servicing Handbook," McGraw-Hill, New York, 1960.

46. Considine, D. M., (Editor), "Process Instruments and Control Handbook," McGraw-Hill, New York, 1957.
47. Gibson, J. E., and Tutuer, F. B., "Control System Components, McGraw-Hill, New York, 1958.
48. Holzbock, W. G., "Instruments for Measurement and Control," Reinhold, New York, 1955.

Electronic Control Circuits

49. Cockrell, W. D., "Industrial Electronics Handbook," McGraw-Hill, New York, 1958.
50. Kloeffler, R. G., "Industrial Electronics and Control," 2nd. Ed., Wiley, New York, 1960.
51. Markus, J., and Zeluff, V., "Handbook of Industrial Control Circuits," McGraw-Hill, New York, 1956.

Technical Papers on Process Control

Dynamics and Control of Processing Units

Distillation Columns: Basic Theory, Transients and Batch Distillation

52. Archer, D. H., and Rothfus, R. R., The Dynamics and Control of Distillation Units and Other Mass Transfer Equipment, AIChE Preprint 2, Joint Automatic Control Conference, MIT, Cambridge, Mass., Sept. 1960.
53. Acrivos, A., and Amundson, N. R., Solution of Transient Stage-wise Operations on an Analog Computer, *Ind. Eng. Chem.*, 45, 467-71 (1953).
54. Armstrong, W. D., and Wilkinson, W. L., An Investigation of the Transient Response of a Distillation Column —Experimental Work and Comparison with Theory, Part II, *Trans. Inst. of Chem. Eng.*, 35, 352-67 (1957).
55. Bowman, J. R., and Briant, R. C., Theory of the Performance of Packed Rectifying Columns, *Ind. Eng. Chem.*, 39, 745-51 (1947).
56. Colburn, A. P., and Stearns, R. F., The Effect of Column Holdup on Batch Distillation, *Trans. AIChE*, 37, 291-309 (1941).
57. Davidson, J. F., The Transient Behavior of Plate Distillation Columns, *Trans. Inst. of Chem. Eng.*, 34, 44-52 (1956).
58. Edgeworth-Johnstone, R., Batch Rectification. Effect of Fractionation and Column Holdup, *Ind. Eng. Chem.*, 35, 407-10 (1943).
59. Edgeworth-Johnstone, R., Batch Rectification. Yields at Finite Reflux Ratios, *Ind. Eng. Chem.*, 36, 1068-70 (1944).
60. Jackson, R. F., and Pigford, R. L., Rate of Approach to Steady State by Distillation Column, *Ind. Eng. Chem.*, 48, 1020-26 (1956).
61. Lamb, D. E., and Pigford, R. L., Dynamic Characteristics and Analog Simulation of Distillation Columns, Paper at 1959 Annual Meeting, AIChE, Dec. 1959.
62. Lapidus, L., and Amundson, N. R., "Stage-wise Absorption and Extraction Equipment, *Ind. Eng. Chem.*, 42, 1071-78 (1950).
63. Pigford, R. L., Tepe, J. B., and Garrahan, C. J., Effect of Column Holdup in Batch Distillation, *Ind. Eng. Chem.*, 43, 2592-2602 (1951).
64. Rijnsdorp, J. E., and Maarleveld, A., Use of Electrical Analogues in the Study of the Dynamic Behavior and Control of Distillation Columns, *Symposium on Instrumentation and Computation in Process Development and Plant Design*, May 1959, *Inst. of Chem. Eng.*, London, pp. A63ff.
65. Rose, A., Johnson, R. C., Theory of Unsteady-State Distillation, *Chem. Eng. Progr.*, 49, 15-21 (1953).
66. Rose, A., Johnson, R. C., and William, T. J., Stepwise Plate-to-Plate Computation of Batch Distillation Curves, *Ind. Eng. Chem.*, 43, 2459-64 (1951).
67. Rosenbrock, H. H., Calculations of the Transient Response of Distillation Columns, *Brit. Chem. Eng.*, 3, 364-7, 432-5, 491-4 (1958).
68. Rosenbrock, H. H., Tavendale, A. B., Storey, C., and Challis, J. A., Transient Behavior of Multicomponent Distillation Columns, *Proc. IFAC Congress*, June-July 1960, Butterworth, London, 1960, pp. 1277-82.
69. Wilkinson, W. L., and Armstrong, W. D., An Approximate Method of Predicting Composition Response of a Fractionating Column, *Chem. Eng. Sci.*, 7, 1-7 (1957).
70. Wilkinson, W. L., and Armstrong, W. D., An Investigation of the Transient Response of a Distillation Column, *Plant and Process Dynamic Characteristics*, Butterworth, London, 1957, pp. 56-72.

Distillation Columns: Column Control

71. Anisimov, I. V., Automatic Control of Rectification Processes, Consultants Bureau, New York, 1959.
72. Aikman, A. R., Frequency Response Analysis of a Fractionating Column, *ISA Journal*, 3, 412-6 (1956).
73. Bauer, R. L., and Orr, C. P., Distillation Control Problems; Application of the McCabe-Thiele Diagram, *Chem. Eng. Progr.*, 50, 312-8 (1954).
74. Berger, D. E., and Campbell, G. G., Experience in Controlling a Large Separation Column with the Continuous Infrared Analyzer, *Chem. Eng. Progr.*, 51, 348-52 (1955).
75. Berger, D. E., and Short, G. R., Sampling and Control Characteristics of Analysis-Controlled Pentane Fractionator, *Ind. Eng. Chem.*, 48, 1027-30 (1956).
76. Coulter, K. E., Applied Distillation, Part IV, Column Control, *Pet. Refiner*, 31, No. 12, 137-8 (Dec. 1952).
77. Hoyt, P. R., and Stanton, B. D., Analyzing Process Control Systems, *Pet. Refiner*, 32, No. 10, 115-9 (Oct. 1953).
78. Lupfer, D. E., and Berger, D. E., Computer Control of Distillation Reflux, *ISA Journal*, 6, No. 6, 34-9 (1959).
79. Rademacher, O., and Rijnsdorp, J. E., Dynamics and Control of Continuous Distillation Columns, *Proc. 5th World Pet. Congress*, Paper 5, Sec. VII, May 1959.
80. Rose, A., and Williams, T. J., Automatic Control in Continuous Distillation, *Ind. Eng. Chem.*, 47, 2284-9 (1955).
81. Wherry, T. C., and Berger, D. E., What's New in Fractionation Control? *Pet. Refiner*, 37, No. 5, 219-24 (1958).
82. Williams, T. J., Instrumentation and Control of Distillation Columns, *Ind. Eng. Chem.*, 50, 1214-22 (1958).
83. Williams, T. J., and Harnett, R. T., Automatic Control in Continuous Distillation, *Chem. Eng. Progr.*, 53, 220-5 (1957).
84. Williams, T. J., Harnett, R. T., and Rose, A., Automatic Control in Continuous Distillation, *Ind. Eng. Chem.*, 48, 1008-19 (1956).

Heat Exchange Equipment

85. Arpaci, V. S., and Clark, J. A., Dynamic Response of Heat Exchangers Having Internal Heat Sources, *Trans. ASME*, 80, 612-34 (1958); *Series C*, 81, 253-66 (1959).
86. Cohen, W. C., and Johnson, E. F., Dynamic Characteristics of a Steam-Water Heat Exchanger, *Ind. Eng. Chem.*, 48, 1031-34 (1956).
87. Dusinberre, G. M., Calculation of Transient Temperatures in Pipes and Heat Exchangers by Numerical Methods, *Trans. ASME*, 76, 421-6 (1954).
88. Dusinberre, G. M., Calculation of Transients in a Cross-Flow Heat Exchanger, *Trans. ASME, Series C*, 81, 61-7 (1959).
89. Fricke, L. F., Morris, H. J., Otto, R. E., and Williams, T. J., Process Dynamics and Analog Computer Simulation of Shell-and-Tube Heat Exchangers, *Chem. Eng. Progr. Symposium Series*, No. 31, 56, 80-85 (1960).
90. Hainsworth, B. D., Tivy, V. V., and Paynter, H. M., Dynamic Analysis of Heat Exchanger Control, *ISA Journal*, 4, 230-5 (1957).
91. Lees, S., and Hougen, J. O., Pulse Testing of a Model

Heat Exchanger, *Ind. Eng. Chem.*, 48, 1064-8 (1956).

92. Masabuchi, M., Dynamic Response and Control of Multipass Heat Exchangers, *Trans. ASME, Series D*, 82, 51-65 (1960).

93. Morris, H. J., The Dynamic Response of Shell-and-Tube Heat Exchangers to Temperature Disturbances, *Proc. IFAC Congress*, June-July 1960, Butterworth, London, 1960, pp. 559-64.

94. Paynter, H. M., and Takahashi, Y., New Method of Evaluating Dynamic Response of Counterflow and Parallel-Flow Heat Exchangers, *Trans. ASME*, 78, 749-58 (1956).

95. Williams, T. J., and Morris, H. J., A Survey of the Literature on Heat Exchanger Dynamics and Control, AIChE Preprint 1, Joint Automatic Control Conference, MIT, Cambridge, Mass., Sept. 1960.

Chemical Reactor Dynamics and Control

96. Aris, R., and Amundson, N. R., An Analysis of Chemical Reactor Stability and Control, *Chem. Eng. Sci.*, 7, No. 3, 121-55 (1958).

97. Beutler, J. A., Programming of Kinetic Calculations for Automatic Computation, *Chem. Eng. Progr.*, 50, 569-74 (1954).

98. Beutler, J. A., and Roberts, J. B., Electronic Analogs in Reactor Design, *Chem. Eng. Progr.*, 52, No. 2, 69F-74F (Feb. 1956).

99. Billingsley, D. S., McLaughlin, W. S., Jr., Welch, N. E., and Holland, C. D., Use of Computers in Reactor Design, *Ind. Eng. Chem.*, 50, 741-52 (1958).

100. Bilous, O. B., and Amundson, N. R., Chemical Reactor Stability and Sensitivity, *AIChE Journal*, 1, 513-21 (1955).

101. Carberry, J. J., First-Order Rate Processes and Axial Dispersion in Packed Bed Reactors, *Canadian J. Chem. Eng.*, 36, 207-9 (1958).

102. Carberry, J. J., and Bulton, R. H., Axial Dispersion of Mass in Flow Through Fixed Beds, *AIChE Journal*, 4, 367-75 (1958).

103. Cholette, A., Blanchet, J., and Cloutier, L., Performance of Flow Reactors at Various Levels of Mixing, *Canadian J. Chem. Eng.*, 38, 1-18 (1960).

104. Cleland, F., Wilhelm, R. H., Diffusion and Reaction in Viscous-Flow Tubular Reactor, *AIChE Journal*, 2, 489-97 (1956).

105. Ebach, E. A., and White, R. R., Mixing of Fluids Flowing Through Beds of Packed Solids, *AIChE Journal*, 4, 161-9 (1958).

106. Kalman, R. E., Lapidus, L., and Shapiro, E., Computer Control of Chemical Processes, *Chem. Eng. Progr.*, 56, 55-61 (1960).

107. Lapidus, L., On the Dynamics of Chemical Reactors, AIChE Preprint 1, Joint Automatic Control Conference, MIT, Cambridge, Mass., Sept. 1960.

108. Levinspiel, O., and Bischoff, K. B., Backmixing in Design of Chemical Reactors, *Ind. Eng. Chem.*, 51, 1431-4 (1959).

109. Stevens, W. F., Chemical Engineering Kinetics, Use in the Scaleup of Chemical Processes, *Ind. Eng. Chem.*, 50, 591-3 (1958).

110. Vlugter, J. C., Chemical Reaction Engineering, *Chem. Eng. Sci.*, 8, No. 1-2, 1-200 (1958).

111. Wehner, J. F., and Wilhelm, R. H., Boundary Conditions of Flow Reactor, *Chem Eng. Sci.*, 6, 89-93 (1957).

112. Williams, T. J., Chemical Kinetics and the Dynamics of Chemical Reactors, *Control Eng.*, 5, No. 7, 100-8 (July 1958).

Fluid Flow Dynamics

113. Alstad, C. D., Isbin, H. S., Amundson, N. R., and Silvers, J. P., Transient Behavior of Single-Phase Natural-Circulation Loop Systems, *AIChE J.*, 1, 417-25 (1955).

114. Alves, G. E., Hydraulic Analysis of Sudden Flow Changes in a Complex Pumping Circuit, *AIChE Journal*, 2, 143-7 (1956).

115. Buckley, P. S., Dynamics of Pneumatic Control Systems, *Instruments & Automation*, 28, 1920-2 (1955).

116. Catheron, A. R., and Hainsworth, B. D., Dynamics of Liquid Level Control, *Ind. Eng. Chem.*, 48, 1042-6 (1956).

117. Ezekial, F. D., The Effect of Conduit Dynamics on Control Valve Stability, *Trans. ASME*, 80, 904-8 (1958).

118. Levenspiel, O., How Much Mixing Occurs in a Pipe, *Pet. Refiner*, 37, No. 3, 1941-4 (Mar. 1958).

119. Oppenheim, A. K., and Chilton, E. G., Pulsating Flow Measurement—A Literature Survey, *Trans. ASME*, 77, 231-48 (1955).

120. Wissler, E. A., Isbin, H. S., and Amundson, N. R., Oscillatory Behavior of a Two-Phase Natural Circulation Loop, *AIChE Journal*, 2, 157-62 (1956).

Process Control Theory

Basic Theory

121. Burrell, C. M., and Lubbock, J. K., What is Control Engineering? *Control*, 1, 16-18, 58-61, 106-10, 171-5, 240-4, 281-5 (1958); 2, 72-6 (1959).

122. Ceaglske, N. H., Fundamentals of Automatic Process Control, *Ind. Eng. Chem.*, 48, 1002-7 (1956).

123. Gibson, J. E., How to Specify the Performance of Closed Loop Systems, *Control Eng.*, 3, 122-9 (Sept. 1956).

124. Gibson, J. E., Nonlinear Systems Design, Part 1: How to Construct a Phase-Plane Plot, *Control Eng.*, 5, No. 10, 69-75 (Oct. 1958); Part 2: How to Interpret the Phase Plane Plot, 6, No. 1, 85-8 (Jan. 1959); Part 3: An Introduction to Synthesis on the Phase Plane, No. 2, 82-85 (Feb. 1959).

125. Higgins, T. J., Basic Books for Your Control Engineering Library, II (Servomechanisms), *Control Eng.*, 1, No. 4, 48-51 (Dec. 1954).

126. Johnson, E. F., Use of Frequency Response Analysis in Chemical Engineering Process Control, I, *Chem. Eng., Progr.*, 51, 353-6 (1955); II, Ibid., 52, No. 2, 64F-68F (1956).

127. Johnson, E. F., Chemical Engineering Process Dynamics, *Chem. Eng. Progr.*, 54, No. 9, 38-9 (Sept. 1958).

128. Meadows, N. G., Basic Transfer Functions, *Control*, 1, No. 1, 25-6 (Jan. 1958); 2, No. 9, 109-10 (Sept. 1959).

129. Naslin, P., A Simplified Theory of Feedback Control Systems, *Process Control and Automation*, 5, 228-31, 274-7, 318-21, 356-9, 408-11, 519-22 (1958); 6, 165-8, 206-9, 273-7 (1959).

130. Powell, B. E., Basic Concepts of Feedback Control, *Control Eng.*, 4, No. 4, 101-5 (Apr. 1957).

131. Williams, T. J., Lauher, V. A., and Young, J. F., Automation Today, *Pet. Refiner*, 35, No. 4, 211-4 (Apr. 1956), No. 5, 205-10 (May 1956), No. 6, 141-4 (June 1956), No. 7, 149-52 (July 1956), No. 8, 161-4 (Aug. 1956), No. 9, 336-40 (Sept. 1956); 36, No. 1, 199-201 (Jan. 1957), No. 2, 155-6 (Feb. 1957), No. 3, 229-33 (Mar. 1957), No. 4, 187-191 (Apr. 1957), No. 8, 166-8 (Aug. 1957), No. 9, 315-8 (Sept. 1957), No. 10, 125-7 (Oct. 1957), No. 11, 305-8 (Nov. 1957); 38, No. 10, 115-8 (Oct. 1959), No. 12, 105-8 (Dec. 1959); 39, No. 1, 171-74 (Jan. 1960), No. 2, 132-6 (Feb. 1960), No. 3, 167-70 (Mar. 1960), No. 4, 173-6 (Apr. 1960), No. 5, 197-200 (May 1960), No. 10, 147-50 (Oct. 1960).

132. Zoss, L. M., How to Reckon Basic Process Dynamics, *Control Eng.*, 3, No. 1, 50-5 (Jan. 1956).

Applied Theory and Examples

133. Aikman, A. R., The Frequency Response Approach to Automatic Control Problems, *Trans. Soc. of Instr. Tech.*, 3, 2-16 (1951).

134. Boyd, D. M., Jr., The Effects of Hysteresis on Derivative Control, *ISA Journal*, 4, 136-40 (1957).
135. Chien, K. L., Hrones, J. A., and Reswick, J. B., On the Automatic Control of Generalized Passive Systems, *Trans. ASME*, 74, 175-85 (1952).
136. Coon, G. A., How to Find Controller Settings from Process Characteristics, *Cont. Eng.*, 3, No. 5, 66-76 (1956).
137. Coon, G. A., How to Set Three-Term Controllers, *Control Eng.*, 3, No. 6, 71-6 (1956).
138. Franks, R. G., and Worley, C. W., Quantitative Analysis of Cascade Control, *Ind. Eng. Chem.*, 48, 1074-9 (1956).
139. Gollin, N. W., Cascade Control Systems, *Control Eng.*, 3, No. 7, 94-8 (July 1956).
140. Goodman, T. P., Determination of the Characteristics of Multi-Input and Nonlinear Systems from Normal Operating Records, *Trans. ASME*, 79, 567-75 (1957).
141. Goodman, T. P., and Reswick, J. B., Determination of System Characteristics from Normal Operating Records, *Trans. ASME*, 78, 259-71 (1956).
142. Gould, L. A., and Smith, P. E., Jr., Dynamic Behavior of Pneumatic Devices, *Instruments*, 26, 886-91, 1026-33 (1953).
143. Graham, D., and Lathrop, R. C., The Synthesis of Optimum Transient Response, *Trans. AIEE, Part 2*, 72, 273-88 (1953).
144. Hall, A. C., Application of Circuit Theory to the Design of Servomechanisms, *J. Franklin Inst.*, 242, 279-307 (1956).
145. Holzmann, E. G., Dynamic Analysis of Chemical Processes, *Trans. ASME*, 78, 251-8 (1956).
146. Hougen, J. O., and Lees, S., Determination of Pneumatic Controller Characteristics by Frequency Response, *Ind. Eng. Chem.*, 48, 1053-63 (1956).
147. Hrones, J. A., and Reswick, J. B., Nondimensional Study of Proportional-Plus-Reset Control of Single-Capacity System, *Trans. ASME*, 73, 511-7 (1951).
148. James, E. W., Organized Process Testing, *Control Eng.*, 3, No. 9, 169-73 (Sept. 1956).
149. James, E. W., Control Systems Engineering—Some Solutions, *Chem. Eng. Progr.*, 54, No. 3, 45-8 (Mar. 1958).
150. Janssen, J. M. L., and Aikman, A. R., A Practical Guide to Plant Controllability, Part I, *Control Eng.*, 2, No. 11, 58-65 (Nov. 1955); Part II, Janssen, J. M. L., 2, No. 12, 54-9 (Dec. 1955).
151. Laspe, C. G., A Practical Application of Transient Response Technique to Process Control Systems Analyses, *ISA Journal*, 3, 134-8 (1956).
152. Powell, B. E., How to Design Control Loops from Frequency Response Data, *ISA Journal*, 5, No. 4, 32-6 (Apr. 1958).
153. Reswick, J. B., Determine System Dynamics Without Upset, *Control Eng.*, 2, No. 6, 50-7 (June 1955).
154. St. Clair, D. W., Coombs, W. F., Jr., and Owens, W. D., Frequency Response Analysis for Industrial Automatic Control Systems, *Trans. ASME*, 74, 1133-47 (1952).
155. Ziegler, J. G., and Nichols, N. B., Optimum Settings for Automatic Controllers, *Trans. ASME*, 64, 759-68 (1942).
156. Ziegler, J. G., and Nichols, N. B., Process Lags in Control Circuits, *Trans. ASME*, 65, 433-44 (1943).
157. Ziegler, J. G., and Nichols, N. B., Valve Characteristics and Process Control, *Instruments*, 22, 75-81 (1949).

Advanced Theory

158. Bertram, J. E., and Franklin, G., Sampled-Data Feedback Improves Systems Response, *Control Eng.*, 2, No. 9, 107-11 (Sept. 1955).
159. Coales, J. F., Problems of Random Inputs, *Process Control and Automation*, 5, 164-8, 184-9 (1958).
161. Gimpel, D. J., Sampled-Data Systems, *Control Eng.*, 4, No. 2, 99-106 (Feb. 1957).
162. Higgins, T. J., A Resume of the Development and Literature of Nonlinear Control-System Theory, *Trans. ASME*, 79, 445-53 (1957).
163. Kochenburger, R. J., Nonlinearity in Controls Systems—Methods of Analysis and Synthesis, *Control Eng.*, 3, 82-91 (Mar. 1957).
164. Oldenburger, R., Optimum Nonlinear Control, *Trans. ASME*, 79, 527-46 (1957).
165. Ragazinni, J. R., and Fadah, L. A., The Analysis of Sampled Data Systems, *Trans. AIEE, Part 2*, 71, 312-24 (1952).
166. Smith, O. J. M., Closer Control of Loops with Dead Time, *Chem. Eng. Progr.*, 53, 217-9 (1957).
167. Stout, T. M., and Kochenburger, R. J., Nonlinearity in Control Systems, *Control Eng.*, 3, No. 2, 55-65 (Feb. 1956); No. 3, 82-91 (Mar. 1956); No. 4, 77-85 (Apr. 1956).
168. Stout, T. M., Basic Methods for Nonlinear Control-System Analysis, *Trans. ASME*, 79, 497-508 (1957).
169. Williams, T. J., and Min, H. S., How Will Analyzers Work With Computer Control, *ISA J.*, 6, No. 9, 89-93 (1959).

Computer Applications

170. Caldwell, W. I., Roundup: 12 Ways of Generating Control Function Pneumatically, *Control Eng.*, 1, No. 9, 58-63 (Sept. 1954).
171. Gibson, J. E., 14 Ways to Generate Control Functions Mechanically, *Control Eng.*, 2, No. 5, 65-9 (May 1955).
172. Hovious, R. L., Morrill, C. D., and Tomlinson, N. P., Industrial Uses of Analog Computers, *Instruments and Automation*, 28, 594-601 (1955).
173. Martinez, H. M., Operational Electronic Analog Computers, *ISA Journal*, 4, 82-8, 141-4 (1957).
174. McCann, G. D., The Direct Analogy Electric Analog Computer, *ISA Journal*, 3, 112-8 (1956).
175. McLeod, J. H., and Leger, R. M., Combined Analog and Digital Systems—Why, When and How, *Instruments and Automation*, 30, 1126-30 (1957).
176. Strong, J. D., A Practical Approach to Analog Computers, *Instruments and Automation*, 28, 602-10 (1955).
177. Williams, T. J., Analog Computing in the Chemical and Petroleum Industries, *Ind. Eng. Chem.*, 50, 1631-5 (1958).
178. Williams, T. J., Johnson, R. C., and Rose, A., Computations in the Field of Engineering Chemistry, *J. of ACM*, 4, 393-419 (1957).

Control Components: Theory, Hardware and Practice

Analytical Instrumentation

179. Aikman, A. R., Process Control by Analytical Instrumentation, *Chem. Eng.*, 64, No. 6, 266-73 (June 1957).
180. Aikman, A. R., How to Solve Analyzer Control Problems, *ISA Journal*, 4, 363-8 (1957).
181. Chaplin, A. L., Some Application Factors Affecting the Regulation of pH in Industry, *Instruments*, 22, 579-87, 608-14, 680-1, 734-8, 804-6, 838-54, 910-1, 950-4, 1010-1, 1040-6, 1107-, 1138-42 (1949); 23, 38-, 86-94, 152-, 194-202 (1950).
182. Combes, J. J., Continuous Analysis, Key to Improved Processing, *Automation*, 3, No. 8, 49-53 (Aug. 1956).
183. Dudenbostel, B. F., Jr., and Priestly, W., Jr., Instrumentation, *Ind. Eng. Chem.*, 48, No. 2, 81A (Feb. 1956), et seq., (monthly column).
184. Dudenbostel, B. F., Jr., and Priestly, W., Jr., Mass Spectrometry, *Chem. Eng. News*, 32, 4737 (1954).
185. Fellows, E. G., Chromatography Analyzes Gas and Vapor Products in the Plant, *Control Eng.*, 4, No. 7, 75-81 (July 1957).
186. Fraade, D. J., Continuous Stream Analysis—Your Key to Process Profits, *Process Control and Automation*, 4, 153-8, 213-7, 269-74 (1957); 5, 300-3, 394-9, 516-8 (1958).
187. Fuller, D. H., Jr., Gas Chromatography in Plant Streams, *ISA Journal*, 3, 440-4 (1956).
188. Glasser, L. G., Photometric Stream Analyzers, *Control Eng.*, 4, No. 10, 87-95 (Oct. 1957)
189. Glasser, L. G., Analyzing and Controlling Products

from Color Measurements, *Control Eng.*, 5, No. 2, 93-8 (Feb. 1958).

190. Glasser, L. G., Refractometers as Process-Stream Analyzers, *Control Eng.*, 4, No. 12, 96-101 (Dec. 1957).

191. Goodwin, P. S., X-Ray Techniques for Analyzing Product Streams—Fluorescence and Diffraction, *Control Eng.*, 5, No. 8, 94-9 (Aug. 1958).

192. Johns, T., Gas Chromatography Applications Manual, Beckman Instrument Co., Fullerton, Calif. (1959).

193. Karp, H. R., Analysis Instrumentation—A Key Factor in Optimizing Industrial Processes, *Control Eng.*, 4, No. 5, 95-101 (May 1957).

194. Maley, L. E., IR Solutions to Five Process Problems, *ISA Journal*, 4, 312-6 (1957).

195. Medlock, R. S., and Wilson, H., Industrial Gas Sampling, *Process Control and Automation*, 4, 403-8 (1958).

196. Menard, R. A., Viscosity as a Process Variable, *Instruments and Automation*, 31, 1212-3 (1958).

197. Munch, R. H., Instrumentation, *Ind. Eng. Chem.*, 43, No. 10, 99A (Oct. 1951), et seq., (monthly column).

198. Noebels, H. J., Continuous Analyzers, Key to Process Automation, *Pet. Eng.*, 29, No. 10, C24-C29 (Oct. 1957).

199. Parry, R. Y., and Hodgson, A. E. M., Fluid Density Measurements by Means of Gamma Ray Absorption, *J. Brit. Inst. of Radio Eng.*, 17, 365-8 (1957).

200. Pleasance, C. L., Continuous Analysis in Nuclear Processing, *ISA Journal*, 5, No. 6, 39-42 (June 1958).

201. Rubin, H., NMR—A New Tool for Moisture Control, *ISA Journal*, 5, No. 1, 64-8 (Jan. 1958).

202. Slater, L. E., Chemical Process Instrumentation in Transition, *Chem. Eng.*, 64, No. 6, 251-8 (June 1957).

203. Smith, V. N., Radioactivity Analyzes Liquids and Gases, *Control Eng.*, 4, No. 8, 86-93 (Aug. 1957).

204. Smith, V. N., Glasser, L. G., and Woodhull, E. N., New Developments in Continuous Chemical Analysis by Optical Methods, *ISA Journal*, 4, 26-9 (1957).

205. Sterling, P. J., and Ho, H., Instrumentation, *Ind. Eng. Chem.*, 52, No. 4, 61A (Apr. 1960), et. seq., (monthly column).

206. Wall, R. F., Infrared Analyzers for In-plant Process Control, *ISA Journal*, 4, 267-71 (1957).

207. Wall, R. F., Mass Spectrometry in Process Control, *Control Eng.*, 5, No. 4, 113-8 (Apr. 1958).

208. Wall, R. F., Instrumentation, *Ind. Eng. Chem.*, 49, No. 2, 73A (Feb. 1957), et seq., (monthly column).

209. Wherry, T. C., Automatic Process Stream Analysis, *Oil & Gas J.*, 125. (May 28, 1956).

210. Wherry, T. C., Chromatography for Process Control, *Chem. Eng. Progr.*, 56, No. 9, 49-57 (Sept. 1960).

Computer Control

211. Eckman, D. P., and Lefkowitz, I., A Report on Optimizing Control of a Chemical Process, *Control Eng.*, 4, No. 9, 197-204 (Sept. 1957).

212. Eisenhardt, R. D., and Williams, T. J., Closed-Loop Computer Control at Luling, *Control Eng.*, 7, No. 11, 103-114 (Nov. 1960).

213. Freilich, A., Process Computer Control Concepts, and Available Computers and What They Do, *ISA Journal*, 6, No. 7, 47-65 (July 1959).

214. James, E. W., and Boksenbom, A. S., How to Establish the Control Problem for an On-Line Computer, *Control Eng.*, 4, No. 9, 148-59 (Sept. 1957).

215. Laspe, C. G., What is Ahead for Digital Computers in Refinery Process Control? *Pet. Eng.*, 29, No. 10, C30-C38 (Oct. 1957).

216. Lefkowitz, I., and Eckman, D. P., Optimizing Control by Model Methods, *ISA J.*, 6, No. 7, 74-7 (1959).

217. Madigan, J. M., Computer Controlled Processing, *Chem. Eng. Progr.*, 56, No. 5, 63-67 (May 1960).

218. Marmorstone, R. J., Process Data Logging Systems, *Instruments and Automation*, 29, 890-4 (1956).

219. Maze, R. O., Converting Process Data into Computer Inputs, *Control Eng.*, 4, No. 9, 176-82 (Sept. 1957).

220. Palevsky, M., A New Approach to Analog-Digital Conversion, *ISA Journal*, 5, No. 4, 42-4 (Apr. 1958).

221. Phister, M., Jr., and Grabbe, E. M., Fitting the Digital Computer into Process Control, *Control Eng.*, 4, No. 6, 129-36 (June 1957).

222. Stout, T. M., and Laspe, C. G., Digital Computers for Process Control, *Ind. Eng. Chem.*, 49, No. 7, 38A-42A (July 1957).

Control Hardware: Description and Use

223. Beard, C. S., Guide for Actuator Selection in Control System Applications, *Automatic Control*, 4, No. 5, 16-18 (May 1956).

224. Beard, C. S., Control Valves, *Instruments and Automation*, 29, 72-3, 282-4, 490-502, 698-703, 895-7, 1124-30, 1306-11, 1528-31, 1782-8, 1986-91, 2220-3, 2412-5 (1956); 30, 82-5; Regulators, 30, 876-9, 1090-7, 1293-7, 1479-83, 1693-8, 1885-8, 2057-60 (1957); 31, 867-70, 1053-58, 1373-76 (1958).

225. Beerblower, A., Controlling Fluid Processes with Continuous Viscometers, *Control Eng.*, 5, No. 6, 107-12 (1958).

226. Boyd, D. M., Jr., Why Electronic Process Control, *Pet. Refiner*, 34, No. 1, 155-8 (Jan. 1955).

227. Brockett, G. F., Electric Control-Valve Operators, *Instruments and Automation*, 31, 111-6 (1958).

228. Cohn, S. D., Performance Analysis of Butterfly Valves, *Instruments*, 24, 880-4 (1951).

229. Combes, J. J., and De Pasquale, M. J., Flow Measuring Devices—Key to Process Control, *Automation*, 4, No. 9, 47-60 (Sept. 1957).

230. Cronan, C. S., Danatos, S., and Olive, T. R. (Editors), Process Control, *Chem. Eng.*, 64, No. 6, 249-320 (June 1957).

231. Henke, R. W., What You Should Know About Velocity Flowmeters, *Control Eng.*, 5, No. 6, 95-100 (1958).

232. Holzbock, W. G., Factors in Selecting Valve Actuators for Electronic Control Systems, *ISA Journal*, 3, 302-307 (1956).

233. Holzbock, W. G., Controllers and Final Control Elements, *Chem. Eng.*, 64, No. 6, 259-62 (June 1957).

234. Kezer, C. F., and Aronson, M. H., Electronic Circuitry, *Instruments and Automation*, 31, 474-5 (1958), et seq., (monthly column).

235. Mamzic, C. L., Improving the Dynamics of Pneumatic Positioners, *ISA Journal*, 5, No. 8, 38-43 (Aug. 1958.)

236. Marton, F. D., Process Control, *Instruments and Control Systems*, 32, 400-2 (1959), et seq.

237. Needham, M. V., Electronic Systems for Industrial Measurement and Control, *Control*, 1, 4-9, 79-82, 102-5 (1958).

238. Nolte, C. B., Principles and Practice of Orifice Metering, *Instruments and Automation*, 29, 716-21 (1956).

239. Olive, T. R., and Danatos, S., *Chemical Engineering* Guide to Process Instrument Elements, *Chem. Eng.*, 64, No. 6, 287-320 (June 1957).

240. Otto, C. R., New Requirements for Control Equipment, *Instruments and Automation*, 27, 608-9 (1954).

241. Reeves, F. E., Recent Developments in Solenoid Valves, *Instruments and Automation*, 29, 1800-6 (1956).

242. Vick Roy, T. R., Data Handling Systems, *Chem. Eng.*, 64, No. 6, 274-79 (1957).

243. Schwent, G. V., McGregor, W. K., and Russell, D. W., Process Control System Design, *ISA Journal*, 3, 218-23, 274-80, 323-9, 426-9 (1956).

244. Valstar, J. E., A Fresh Look at Selecting Control Valve Characteristics, *Control Eng.*, 6, No. 3, 103-8 (Mar. 1959); How Piping Influences Valve Performance, No. 4, 123-5 (Apr. 1959); Sizing Valves for Maximum Flow and Control Rangeability, No. 5, 120-2 (May 1959); How to Reduce Interaction Between Control Loops, No. 6, 112-3 (June 1959).

Constant Rate Lab Feeder Can Be Adapted to Plant

The "Mariotte Bottle," well known as a laboratory feeder, can be adapted in principle to plant-scale operations by interposing such a vessel of moderate size between feed tank and process.

★ Winner of the October Contest by

C. F. A. ROBERTS, *Supt., Plant Investigations Dept., Orr's Zinc White Ltd., Widnes, England.*

A common problem in the process industries is that of integrating batch and continuous processes to give steady operation. Difficulty arises, for example, where the product of an earlier batchwise stage is delivered from a surge tank containing a variable supply to a subsequent continuous reaction step. Then, special means must be used to provide the constant reactant flow required by the continuous step.

This can be done with flow meters or controllers, with metering pumps or constant-level tanks, of course, but sometimes such equipment is not quickly available, or we may want to save the expense. In the laboratory, an elegant way of tackling the problem is the so-called Mariotte bottle, the principle of which is illustrated by the solid lines in the sketch. The idea is adapted readily enough to somewhat larger vessels for the pilot plant, but may not be suitable for the large-sized feed vessels needed in commercial-scale operations. How to overcome this problem on a plant scale is our present subject.

In the sketch, as liquid leaves vessel *X* at *A*, air is sucked in and bubbles up from *B*, which is consequently always at atmospheric pressure. This then ensures a constant head and a steady flow. When we used this on a pilot-plant scale, *C* was a calibrated valve for setting the desired flow rate and *D* a shutoff valve to avoid the need for upsetting the adjustment of *C*. To make certain of steady conditions in starting a full tank, we applied vacuum at *E* until bubbles showed at *B*, then closed valve *F*. Inspection glasses showed the liquid level.

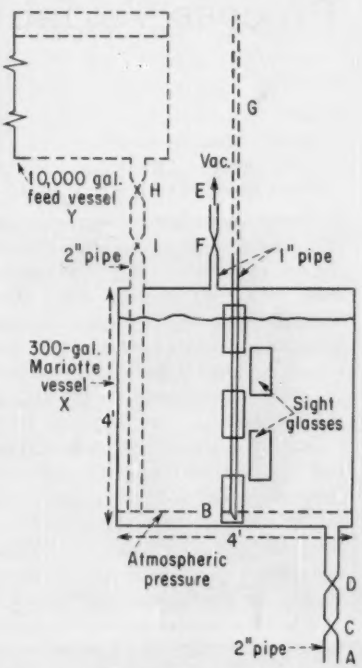
In going to full scale, we were unable to apply this principle to the necessary 10,000-gal. feed tank for several reasons. We could not be sure of achieving an air-tight seal and it was also necessary to be able to fill and sample the tank. Our 300-gal. pilot-plant tank would have to be refilled every couple of hours, requiring the process to be shut down. Might it be possible instead to refill the 300-gal. feed tank as fast as it was emptied, perhaps using a succession of vessels?

The "obvious" solution we finally hit on appears in the dotted lines of the sketch. Our feed tank *Y* is covered but not hermetically sealed. It is connected to the Mariotte tank through shutoff valve *H* and calibrated valve *I*, while the air inlet pipe *G* is extended as high as the feed tank to eliminate overflow.

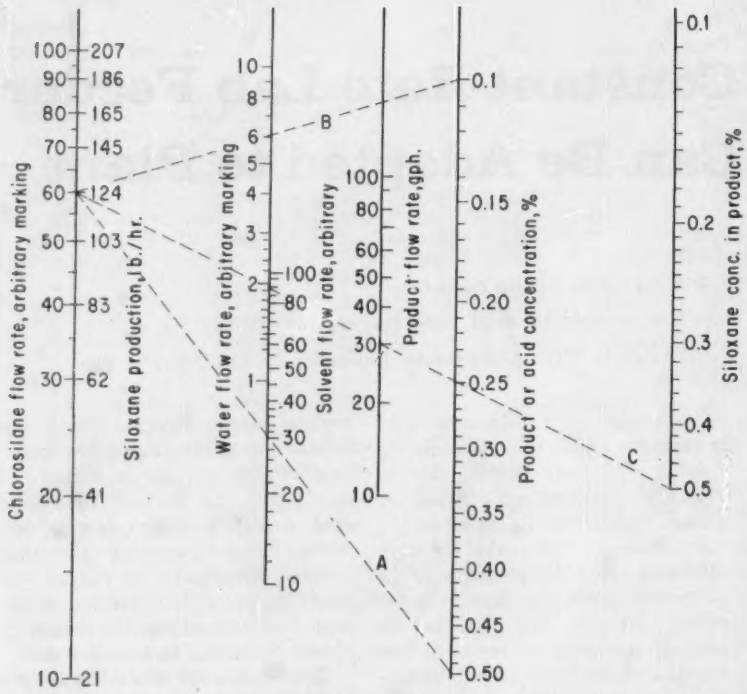
We start with both tanks full, open both shutoff valves *H* and *D* and then adjust valve *C* for the required flow rate. A vigorous stream of bubbles emerges from *B*. Valve *I* is opened until the bubbles almost stop, i.e., one bubble every couple of minutes. The ideal is a bubble just hovering on the tip of *B*.

The output from *A* will remain constant as long as there is any liquor in the Mariotte vessel, regardless of the level in feed tank *Y*. However, as the level in *Y* drops, the inflow to *X* will fall below its output at *A*, as shown by an increase in the bubbling rate at *B*. This warns the operator to open valve *I* slightly, until the flow of bubbles nearly stops. Thus, the bubble flow at *B* acts as a flow meter to guide the operator in setting *I*—but it has the further advantage that it will hold the flow steady while he is attending to other duties. Eventually, of course, the Mariotte vessel will become empty and need recharging, the length of "run" depending on operator skill.

Dimensions for this setup are not critical. In general, the feed tank should be relatively shallow and mounted as high as possible, while the Mariotte vessel should be as large as possible.



Solid lines show Mariotte Bottle idea; dotted lines, how the idea is expanded.



Nomograph relates continuous process variables, enables nontechnical personnel to determine what results will follow from operating-condition changes.

Process Variables by Chart

GORDON MARINE
Chemical Engineer
Dow Chemical Co., Midland, Mich.

Shown above is a nomograph that has proved to be a valuable operating aid in relating the process variables in a continuous process. We have used it in our pilot plant to help the operators control a process where a chlorosilane is hydrolyzed in a solvent solution to produce a diluted siloxane and aqueous HCl.

In the process, the chlorosilane and the solvent enter the system through positive-displacement metering pumps, while the water enters through a rotameter. The equipment operates at various rates to produce various concentrations.

When the equipment was first put into operation, we found two problems: (1) It was necessary to convert the arbitrary calibrations of the pumps and the rotameter to actual flow rates, in order to perform the calculations needed for finding the settings that give the desired throughput rates and concentrations. (2) Since the operators were unfamiliar with the mathematics needed to make these calculations, it was necessary for them to consult the supervisors every time the settings were to be changed, to learn what the flow rates and concentrations would be.

We took care of both problems by constructing the nomograph and placing it on the equipment instrument panel, along with instructions on its use. It was a simple matter for anyone to find what pump and rotameter settings were needed for desired rates and concentrations.

The nomograph also serves as a convenient way of learning whether the equipment is malfunctioning. Operating personnel can quickly determine the concentrations of both the siloxane and acid solutions by checking their specific gravities. Thus, any error in operation of the metering equipment is obvious.

Each process will, of course, have its own nomograph. However, it may be worthwhile to show briefly how the present one was developed. Having checked into the relations between the arbitrary calibrations of the pumps and meter and the actual flows, and into the relation between chlorosilane fed and siloxane and acid produced, we set up three equations, which were then converted into logarithmic form and used in the construction of the nomograph by usual methods.

First we set up an equation relating the concentration of siloxane produced, in terms of the settings of the chlorosilane and solvent pumps. Line *A* shows the result as expressed on the nomograph. Then we related the concentration of acid produced to the settings of the chlorosilane pump and the water rotameter. Line *B* shows this result. Finally, we related chlorosilane feed rate in terms of the equivalent siloxane output in pounds/hr., with the resultant concentration of product siloxane, to give flow rate of siloxane solution, see Line *C*.

COMING JANUARY 23

Calibrate Explosive Meter With Solvent Stream

By W. A. Dickens
Winner of the Nov. Contest

★ How Readers Can Win

$50 Prize for a Good Idea—Until further notice the Editors of *Chemical Engineering* will award $50 each four weeks to the author of the best short article received during that period and accepted for publication in the Plant Notebook. Each period's winner will be announced in the second following issue and published in the fourth following issue.

$100 Annual Prize—At the end of each year the period winners will be rejudged and the year's best awarded an additional $100 prize.

How to Enter Contest—Any reader (except a McGraw-Hill employee) may submit as many contest entries as he wishes. Acceptable material must be previously unpublished and should be short, preferably not over 500 words, but illustrated if possible. Acceptable nonwinning articles will be published at space rates ($10 minimum).

Articles should interest chemical engineers in development, design or production. They may deal with useful methods, data, calculations. Address Plant Notebook Editor, *Chemical Engineering*, 330 W. 42 St., New York 36, N. Y.

HOW *HERCULES* HELPS...

PACKAGE BEAUTY—For a merchandising *plus* in its new line of children's cosmetics, Avon turned to Hi-Fax,® Hercules high-density polyethylene. Hi-fax pioneered the break-through for plastic detergent bottles and is now finding increasing use in household chemical, drug and cosmetic packaging. The first material approved by both producers and users of plastic containers, Hi-fax continues to lead the way.

CHEWING GUM—This enormous mass is undoubtedly the largest wad you will ever see. Here it is being given added "chewability" through the use of a masticatory substance such as Staybelite Ester® 5, which is exempt from the Food Additive Amendment for chewing gum use. Other Hercules ingredients that are useful in this $187,000,000 industry as masticatory substances are Ester Gum 8D, Poly-pale® Ester 10, and Hercolyn® D.

SOLVE INTRICATE PROBLEMS—Tiny propellant charges for Giannini "Pyrogyro" provided a practical solution to the problem of smaller, lighter, more effective and less expensive gyroscopes for missile applications. Gases generated by the precision propellant charge bring the gyro rotor up to speeds greater than 36,000 revolutions per minute within 0.1 second after ignition.

HERCULES POWDER COMPANY
INCORPORATED
Hercules Tower, 910 Market Street, Wilmington 99, Delaware

Q60-10

CHEMICAL MATERIALS FOR INDUSTRY

HERCULES

No. 47 DUCTWORK

R. T. WITHERSPOON

The Chemstrand Corp., Pensacola, Fla.

Data tabulated in this Cost File are based on a complete, installed ductwork system, including various runs and bends. Ductwork was fabricated in a sheet-metal shop and delivered to the erection site. Based on work of an outside contractor, it's believed that the figures are also good for a plant maintenance crew if labor is multiplied by 1.10.

Date of reference is July 1960.

Ductwork

Duct Size		Galv. Steel		Aluminum	
Rectangle Max. Side, In.	Round Dia., In.	USS Gage	Lb./ Sq. Ft.	B & S Gage	Lb./ Sq. Ft.
Up to 12	6–18	26	0.906	24	0.284
13–30	19–24	24	1.156	22	0.357
31–60	25–39	22	1.406	20	0.452
61–90	40–48	20	1.656	18	0.569
91 and up	49 and up	18	2.156	16	0.717

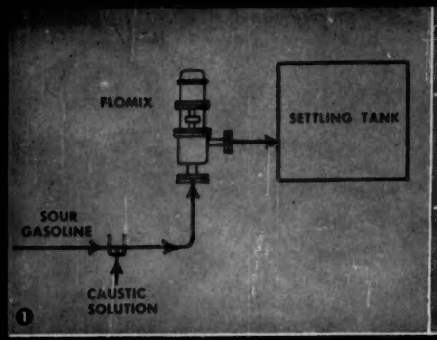
Duct Cost

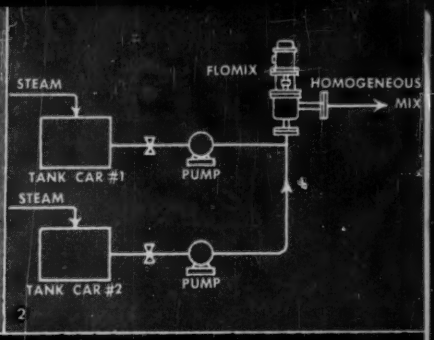
	Material Cost/ Lb.	Fabricate Cost/ Lb.	Erect Cost/ Lb.	Total Cost/ Lb.	Man-Hr./ Lb., Fab. & Erect
Galvanized duct	$0.17	$0.30	$0.40	$0.87	0.23
Aluminum duct*	0.50	0.97	1.28	2.75	0.72
302 SS duct	1.05	0.30	0.60	1.95	0.29
20-oz. copper duct	1.10	0.30	0.60	2.00	0.29
Galbestos duct	0.28	0.30	0.60	1.18	0.29
Transite pipe (Note that costs for transite pipe are on a per-foot basis)					
4-in.	0.75	——	0.64	1.39	0.21
5-in.	0.95	——	0.64	1.59	0.21
6-in.	1.14	——	0.64	1.78	0.21
7-in.	1.38	——	0.69	2.07	0.22
8-in.	1.83	——	0.69	2.52	0.22
10-in.	2.42	——	0.75	3.17	0.24
12-in.	3.03	——	0.80	3.83	0.26
14-in.	3.86	——	0.91	4.77	0.29
16-in.	4.42	——	1.11	5.53	0.36
20-in.	5.54	——	1.27	6.81	0.41
24-in.	6.64	——	1.44	8.08	0.46
30-in.	8.28	——	1.83	10.11	0.59

* On pound basis, approximately three times as much ductwork can be shop-fabricated and erected in aluminum as in steel. Cost of duct in place is about the same.

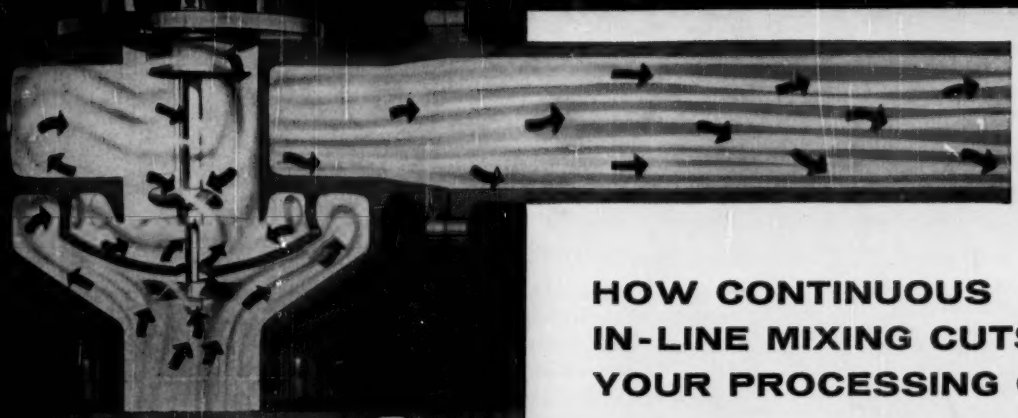
Cost File Index—1960

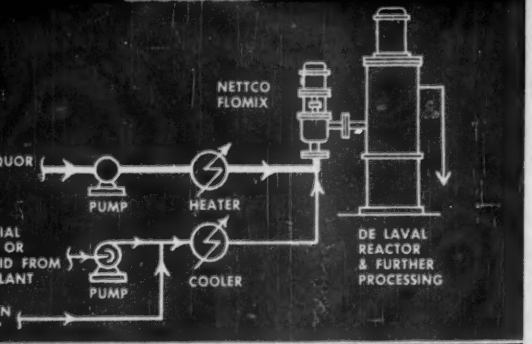
No.	Subject	Author	Issue	Page
22	Process control instrumentation	Vilbrandt & Dryden	Jan. 11	p. 124
23	Estimating process instrumentation	J. W. Bernard	Jan. 25	p. 120
24	Construction equipment rental rates	C. A. Adams	Feb. 8	p. 146
25	Unit construction costs: warehouses	A. R. Sellers	Feb. 22	p. 151
26	Ibid.	Ibid.	Mar. 7	p. 152
27	Process equipment nomograph	Walas & Spangler	Mar. 21	p. 173–6
28	Welded & seamless tubing	Babcock & Wilcox	Apr. 4	p. 156
29	Analysis of ethylene plant costs	Haselbarth & Berk	Apr. 18	p. 194
30	Labor factors; motor starters	Michel, E. W.	May 2	p. 142
31	Chemical plant cost breakdown	Haselbarth & Berk	May 16	p. 158
32	Estimating engineering drafting costs	D. F. Brosnan,	May 30	p. 114
33	Labor factors; centrifugal pumps	W. R. Kane	June 13	p. 232
34	Labor factors; motor starters	E. W. Michel	June 27	p. 134
35	Rapid estimating for pressure vessels	A. J. Reilly	July 11	p. 146–50
36	Plate-and-frame filters	J. L. Hutton, Jr	July 25	p. 132
37	Labor factors; heat exchangers	D. F. Brosnan	Aug. 8	p. 152
38	Labor factors; motors	E. W. Michel	Aug. 22	p. 148
39	Centrifugal separators	J. C. Smith	Sep. 5	p. 148–50
40	Labor factors; electric panels	E. W. Michel	Sep. 19	p. 208
41	Computers in cost estimating	——	Oct. 3	p. 119
42	Factors in cost estimating	W. F. Wroth	Oct. 17	p. 204
43	Storage & process tanks	W. F. Wroth	Oct. 31	p. 124
44	Valuation & depreciation	J. E. Haselbarth & J. M. Berk	Nov. 14	p. 244
45	Ibid.		Nov. 28	p. 146
46	Cost-capacity data	J. M. Berk & J. E. Haselbarth	Dec. 12	p. 172
47	Ductwork; index	R. T. Witherspoon	Dec. 26	p. 110

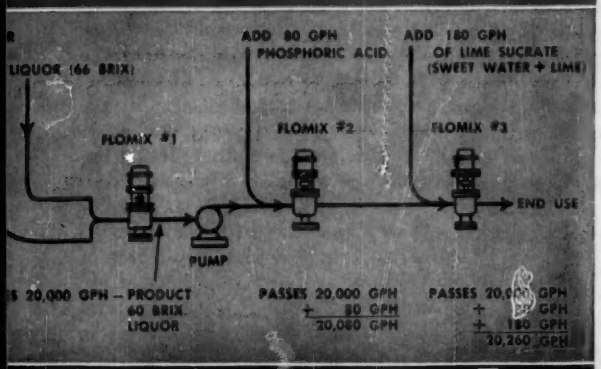


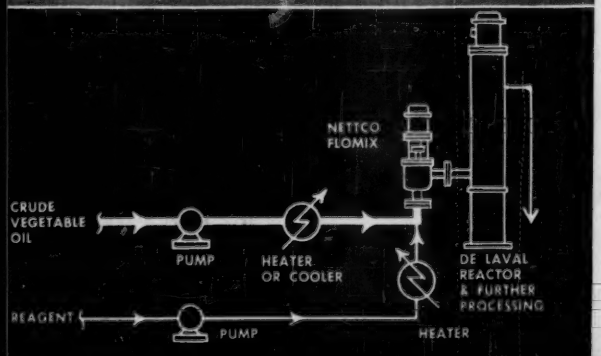


Improved Processing through Engineered Agitation






LIQUOR (66 BRIX)
ADD 80 GPH PHOSPHORIC ACID
ADD 180 GPH OF LIME SUCRATE (SWEET WATER + LIME)
FLOMIX #1
FLOMIX #2
FLOMIX #3
END USE
PUMP
20,000 GPH — PRODUCT 60 BRIX LIQUOR
PASSES 20,000 GPH + 80 GPH 20,080 GPH
PASSES 20,000 GPH + GPH + 180 GPH 20,260 GPH



HOW CONTINUOUS IN-LINE MIXING CUTS YOUR PROCESSING COSTS!!

NETTCO'S UNIQUE FLOMIX® CUTS PROCESSING COSTS by eliminating intermediate storage tanks and mixing vessels . . . by simplifying piping layouts . . . by providing fast, uninterrupted processing.

THE VERSATILE NETTCO FLOMIX COMBINES liquids, solids and liquids, or gases and liquids which, in combination, will readily flow through piping. In mixing, blending, reacting, washing, contacting, bleaching, absorbing, chlorinating, clarifying and other operations, Flomix can give you new processing efficiencies.

IF YOUR PROFIT MARGINS ARE SHRINKING, your NETTCO representative . . . with a full line of Flomix, side drive, tank top, portable and tripod mixers . . . can advise you on how low cost mixing can put more profit in your process. See Chemical Engineering Catalog or Refinery Catalog for his address or write for Bulletin 531A, Nettco Corporation, 87 Tileston St., Everett 49, Massachusetts.

NETTCO

ENGINEERED AGITATION SPECIALISTS
EVERETT 49, MASSACHUSETTS

1 In Refinery Caustic Wash Process.
2 On-the-spot, uniform mixing of liquids of varying viscosities from tank cars.
3 In DeLaval Continuous Centrifugal Tall Oil Process.
4 In Defecation Process in Sugar Refinery.
5 In DeLaval Hermetic Continuous Centrifugal Vegetable Oil Refining Process.

CORROSION-CONTROL DESIGN 7b

Last part of a series published throughout 1960.

Fabrication: Key to Mixer Corrosion

Fabricating techniques (cast, welded or bolted), blade angle, shaft bearings and shaft sealing devices, all play a vital role in minimizing mixer corrosion.

NORMAN H. PARKER
*Tower Iron Works, Inc.**

We have already mentioned that design of the mixing device itself may affect degree of corrosion, and we have outlined the basic impeller types, and flow patterns they develop. Let us now examine the construction of various impellers.

Basically, there are three ways to manufacture mixing impellers. The first is to cast the impeller, in one or more pieces. The second is to make it as a weldment. The third is to make it as a combination weldment with bolted parts.

Most propellers used in mixing applications are cast (as large as 8-ft. dia.) because of the blade form, and the ease of machining and balancing (Fig. 1).

Turbine impellers, either the straight or back-sloped blade design (Fig. 2) can be of cast, fabricated weldments, or bolted construction. Turbines with blades set at an angle to the vertical centerline (Fig. 3) are usually cast rather than fabricated.

► **Cast Impellers** — Each of these manufacturing procedures has at least one drawback.

Castings have a basic cost disadvantage (heavy sections required, as well as relatively high manufacturing costs). Advantages, however, that can offset this include uniformity of the material of construction, streamlined surfaces and a case-hardening effect due to more rapid cooling of the outer surface in contact with the mold. Case hardening will increase wear-life when the impeller is used in abrasive service. Streamline surfaces also reduce the possibility of corrosion starting at sharp edges. However, it must be the primary responsibility of the manufacturer and ultimately the buyer to reject castings containing sand, blowholes or surface imperfections that would be potential trouble spots in corrosive service.

► **Welded Impellers**—With welded impellers manufactured out of corrosion-resistant alloys, there is the possibility of producing a structural change in the material, which will alter the degree of corrosion resistance. In addition, corrosion is known to be accelerated by weld projections and/or roughness. Usual welded construction puts the welded areas as close as possible to the impeller hub, where flow velocity is lowest. However, this does not eliminate the problem, unless utmost care is taken, and proper carbon stabilizing materials are employed. In Fig. 4, the arrows indicate potential corrosion locations. Welding or welded areas near the impeller tips should be avoided because they would be at or near the zone of highest velocity flow.

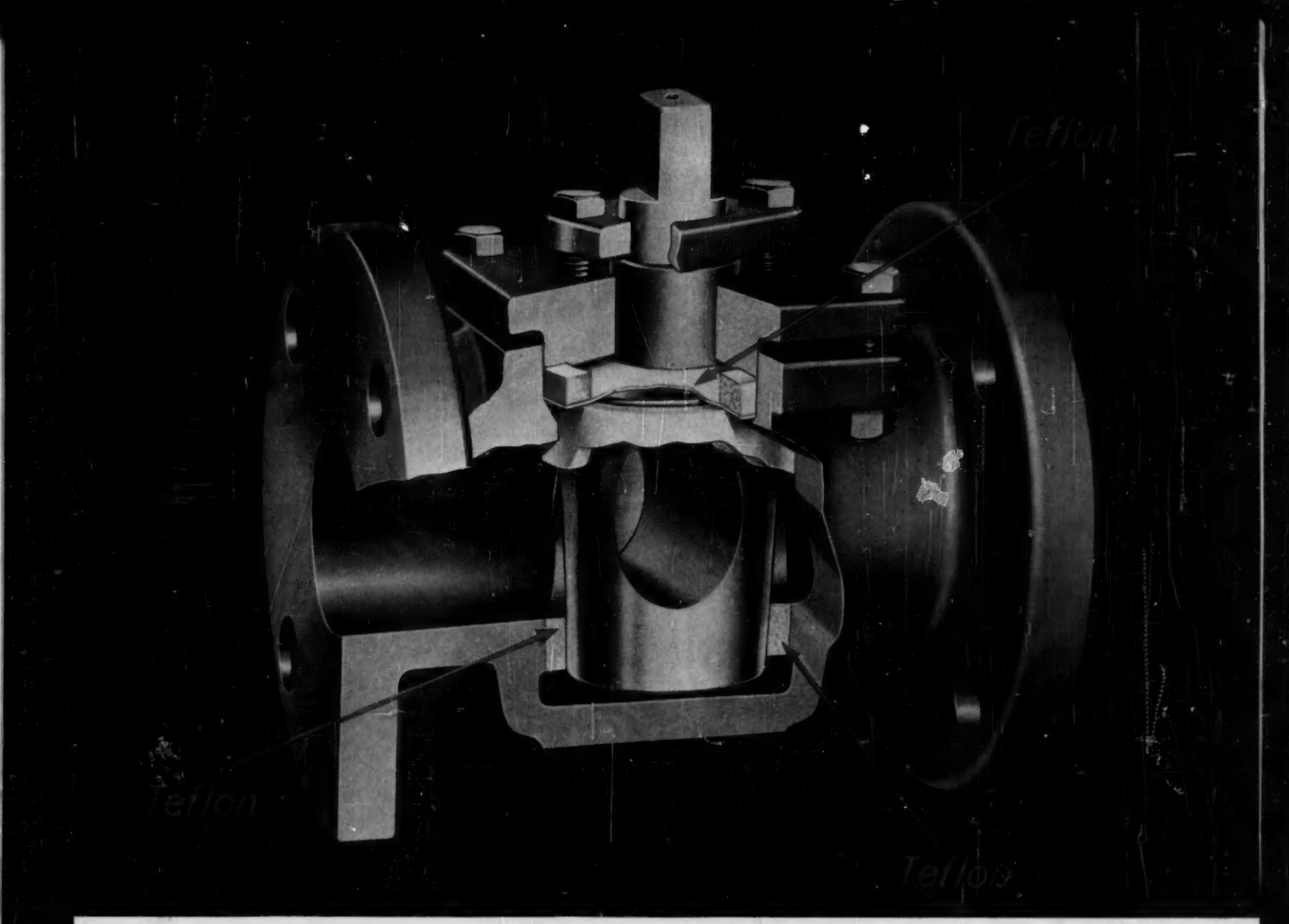
► **Bolted Types**—Bolted mixing impeller designs vary from one manufacturer to another. It is possible to find impellers with blades bolted at the hub, at a point two-thirds of the diameter, and sometimes at the tips. Here again, if bolted construction is absolutely necessary, as in the case of putting a 6-ft.-dia. impeller through an 18-in. manhole, the best place for the bolts is at or near the hub, where the liquid velocity is lowest.

The principal cause of failure of bolted construction is crevice corrosion, due either to low oxygen concentration or high metal-ion con-

* For author biography, see *Chem. Eng.*, Dec. 12, 1960, p. 194.

Previous articles in this series

1. Plant Site, Layout Minimize Corrosion, Jan. 11, 1960, p. 144.
2. Proper Design Voids Equipment Corrosion, Feb. 22, 1960, p. 162.
3a. Often Overlooked Reactor Design Factors, May 2, 1960, p. 150.
3b. Keys to Corrosion-Wise Reactor Design, May 16, 1960, p. 170.
4a. Valve Design: Special for Corrosives, June 13, 1960, p. 238.
4b. Valves for Severe Corrosive Service, June 27, 1960, p. 146.
5a. How to Extend Storage-Tank Life, July 25, 1960, p. 148.
5b. Design Tips Reduce Tank Failures, Aug. 8, 1960, p. 154.
6. Better Design Stretches Exchanger Life, Oct. 17, 1960, p. 214.
7a. Guides to Reducing Agitator Failures, Dec. 12, 1960, p. 190.



THROW OUT LUBRICATED PLUG-VALVE PROBLEMS

Install non-lubricated DURCO Type G SLEEVELINE® valves

Wherever you have cast iron or semi-steel valves that stick, gall, break, leak thru, or otherwise cause maintenance nightmares, install ductile iron Durco Type G valves with Teflon sleeves.

Durco SLEEVELINE valves are available in ductile iron or stainless steel, screwed or flanged ends, from ½" through 6", with 150 psi rating.

Write today for your copy of Bulletin V/12.

DURCO
Serves the Process Industries

THE DURIRON COMPANY, INC., Dayton, Ohio / Valves • Pumps • Filters • Process Equipment

Impellers: cast, welded or bolted?

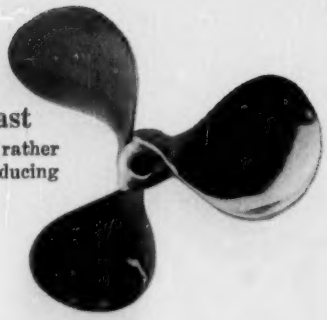


Fig. 1— Propellers are usually cast
Most propellers, with simple blades, are cast (rather than fabricated by welding or bolting), producing streamlined surfaces.

Fig. 2— Turbines offer variety
Turbine impellers with blades vertical to the centerline are available as castings, fabricated weldments, or bolted.

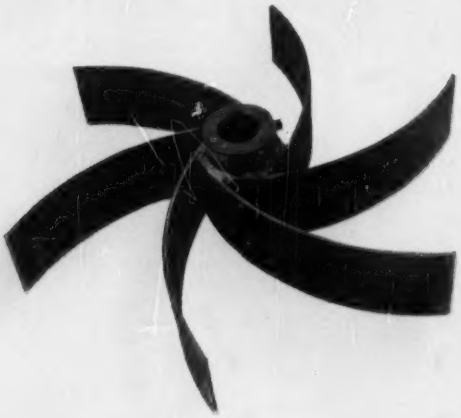
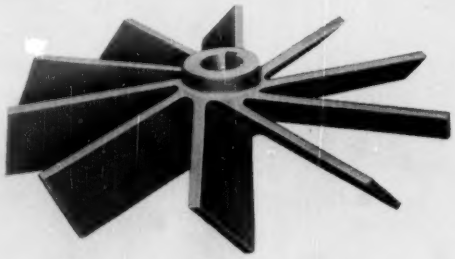


Fig. 3— Cast angled blades
Turbines with blades set at an angle to the centerline are usually cast rather than fabricated.



centration cells (see *Chem. Eng.*, June 13, 1960, p. 240). Fig. 5 shows the spots at which this type of corrosion would appear in a bolted-impeller design. There is an advantage, when bolted construction is used, to having no exposed threads but this does not eliminate the possibility of crevice corrosion. Another practice to be avoided at all costs is the use of socket-head set screws. Only a small amount of corrosion in the socket will make it necessary to drill the screws out when they have to be removed.

Both bolted and welded impellers are least suited to combined abrasion and corrosion service. Welded areas, and any bolts that are exposed to the flow of slurries, are sources of potential failure.

▶ **Blade Shapes**—Another impeller design factor that can contribute to corrosion problems is the blade shape. Essentially, there are two basic shapes: straight (blades that extend on a radial line) and back-sloped (blades that slope back from the direction of rotation). The blades, whether straight or back-sloped, need not extend back to the hub. The center-disk impeller, Fig. 6, can have either type of blade.

Basically, the straight-blade, as pointed out by Lyons and Parker,* develops a higher discharge velocity than the back-sloped blade, with intense localized shear. Since corrosion rate increases with velocity and with turbulence—a product of high shear—this blade shape is subject to more corrosion problems than the back-sloped blade. Wear on the back side of the blade is more likely to appear as a result of high turbulence. However, both blade shapes are subject to this type of abrasion wear in high-density slurries.

▶ **Shaft Problems** — Generally, mixer shafts do not have corrosion problems as severe as the mixing impellers themselves.

With turbine impellers, unless there is liquid-level variation, and for a short time strong vortexing, the shaft is in the lowest liquid velocity zone. The situation is different for propeller or axial-flow devices.

For both types of impellers, any serious problem would be expected to develop at the point at which the hub is located. Here, the shaft is machined for a key, and at least one, but usually two, set screws. This is a good arrangement for crevice corrosion. A less likely problem, but possible, is galvanic corrosion, if the materials of construction of the shaft, impeller and/or set screws were different.

At one time, most shaft problems developed where the steady or guide bearing was located. With the combination of abrasive wear from metal-to-metal contact and the presence of corrosives, the shaft in the area of the steady bearing was subject to rapid failure. However, the introduction of split guide bearings and shaft wear sleeves considerably

* Lyons, E. J., N. H. Parker, *Chem. Eng. Progr.*, 50, 629 (1954).

BONDSTRAND®

An imaginative solution to your piping problems

From Missile Research...

A new product for process piping

- Twice as strong as steel
- 1/4 the weight of steel
- Inherently resistant to chemicals which attack stainless steel

Bondstrand is a corrosion-resistant, high strength, rigid pipe made of glass filaments bonded in chemically inert synthetic resins. It is capable of withstanding high pressure and the corrosive attack of many salt, acid, and alkaline solutions. The outside surface is equally resistant because the pipe is made entirely of corrosion-proof materials. No painting or maintenance is necessary.

Bondstrand's light weight and ease of assembly can save up to 50% of installation costs. Actual cost records of typical applications prove that the total installed cost averaged only 1.3 times that of carbon steel pipe. By eliminating the corrosion problem and down time for replacement or repair, Bondstrand saves many times its slightly higher initial cost.

Bondstrand is now available in sizes from 2" through 8" with all necessary couplings and fittings. Larger sizes available on special order.

Write for bulletin containing complete data, including physical properties, chemical resistance, flow rates, and other design information.

Amercoat® CORPORATION

125

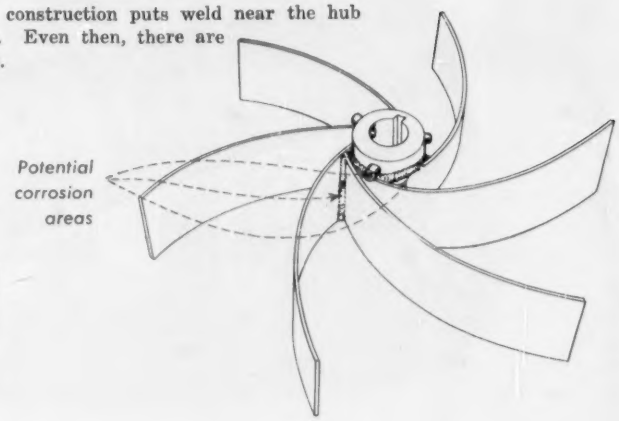
A Subsidiary of American Pipe and Construction Co.

Dept. AL 4809 Firestone Blvd., South Gate, California

921 Pitner Ave., Evanston, Ill. • 360 Carnegie Ave., Kenilworth, N.J. • 111 Colgate, Buffalo, N.Y. • 2404 Dennis St., Jacksonville, Fla. • 6530 Supply Row, Houston, Tex.

Welds and bolts present corrosion problems

Fig. 4—Welded construction
Good design for welded construction puts weld near the hub where velocity is lowest. Even then, there are potential corrosion areas.



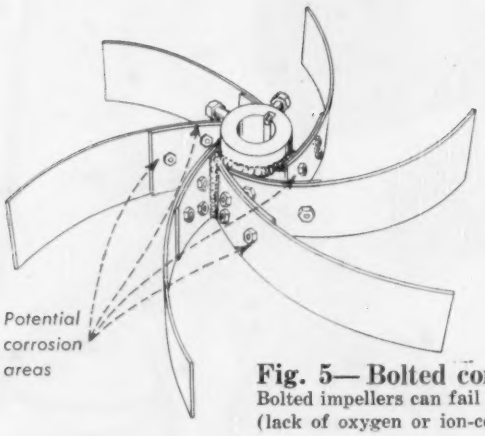


Fig. 5—Bolted construction
Bolted impellers can fail because of crevice corrosion (lack of oxygen or ion-concentration cells).

reduced this problem. But, bolts in the split-bearing design, and for attaching the shaft sleeves—as necessary as they may be—are sources of crevice corrosion.

Today, advances made in understanding and treating shaft flexure under overhung load conditions permit use of longer unsupported shafts. This is reducing the necessity for steady bearings and their attendant problems.

► **Shaft Seals**—In vertical-tank applications, the shaft sealing device is subject to vapor-space corrosion: basically, any attack will result from excessive concentrations of corrosive material. Severity of this attack will depend upon the type of sealing device construction.

There are two basic packed seals: one projects into the tank and the other has its major proportions above the mounting flange.

The in-tank design has two disadvantages: the seal housing must be of special material suited to the corrosion application (this means it is a high-cost item) and since the housing is in the tank, it offers a natural condensation surface under certain conditions.

With the outside housing, only the face of the flange and a relatively small area need be of a special corrosion-resistant material. Those parts are outlined in color in Fig. 7. Balance of the material of construction may be of carbon steel. The assumption must be made that the box will be packed properly and with a suitable material. Under those conditions, no vapor will reach the carbon-steel housing.

However, on a side-entering mixer, the entire housing, whether it projects into the tank or is outside the flange, should be of a cor-

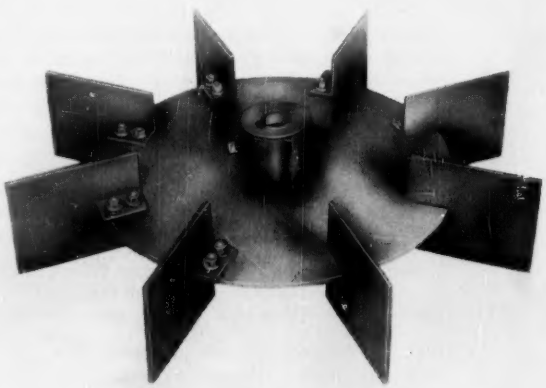


Fig. 6—Center disk impeller has blades that do not extend back to the hub. Blades can be straight or slope back from the direction of rotation.

Sealing devices must be protected

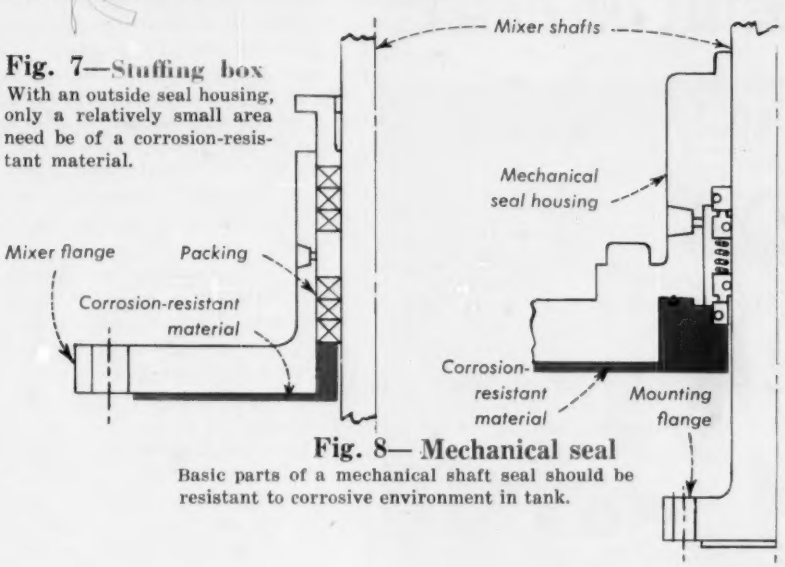


Fig. 7—Stuffing box
With an outside seal housing, only a relatively small area need be of a corrosion-resistant material.

Fig. 8— Mechanical seal
Basic parts of a mechanical shaft seal should be resistant to corrosive environment in tank.

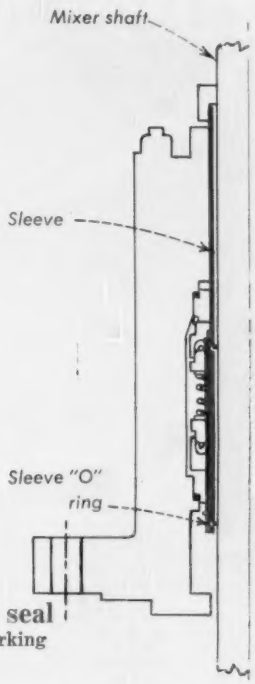


Fig. 9— Sleeve on mechanical seal
Sleeve on mechanical seal protects working parts and only sleeve need be resistant.

rosion-resistant material. With any liquid head, even the most carefully packed box will permit some liquid to weep into it—a condition that will become worse as time passes and the packing wears. The same applies to housings that are water-cooled in top-entering applications. Because of the possibility of internal condensation and/or crystallization from the vapor, the housing should be of a corrosion-resistant material.

► **Mechanical Seals**—While on the subject of sealing devices, we should not overlook the mechanical seal. In the writer's opinion, this type of shaft seal has been oversold for agitator applications. There are definite services in which they can be used to advantage, but as a general replacement for the packed box in most services, they leave quite a bit to be desired. First, mechanical seals require the optimum in mechanical design of the mixer, straightness of shaft, alignment of bearings, and minimization of shaft flexure, combined with the services of a true master mechanic for installation and maintenance. Even factory installation and run in does not assure perfect operation in the field. Since they are delicate mechanisms wit close clearance parts, they should not be shipped installed on the shaft.

In the design of the mechanical-seal housing above the flange, there are several factors to be kept in mind if problems are to be avoided. Fig. 8 illustrates a basic design. Here, the areas that absolutely should be of corrosion-resistant material are outlined in color. Whether it is necessary that the lubricant be compatible with the products in the tank, or be one of the tank components, will determine whether the housing material need be anything other than carbon steel.

► **Seal Refinement** — An improvement, which simplifies installation of mechanical seals, involves use of a sleeve on which all the mechanical seal parts are mounted (Fig. 9). This sleeve, machined to close tolerances to the O.D. of the shaft, must have some gasketing between it and the shaft to seal the tank contents from the atmosphere. The proper location of these gaskets, usually Teflon "O" rings or wedges, is most important.

They prevent corrosion between the sleeve and the shaft. The sleeve must be of a corrosion-resistant material, since it usually extends below the face of the mounting flange, and the exposed surfaces are subject to vapor-phase corrosion. Without properly located gasketing, corrosion or possibly product crystallization could freeze the sleeve to the shaft.

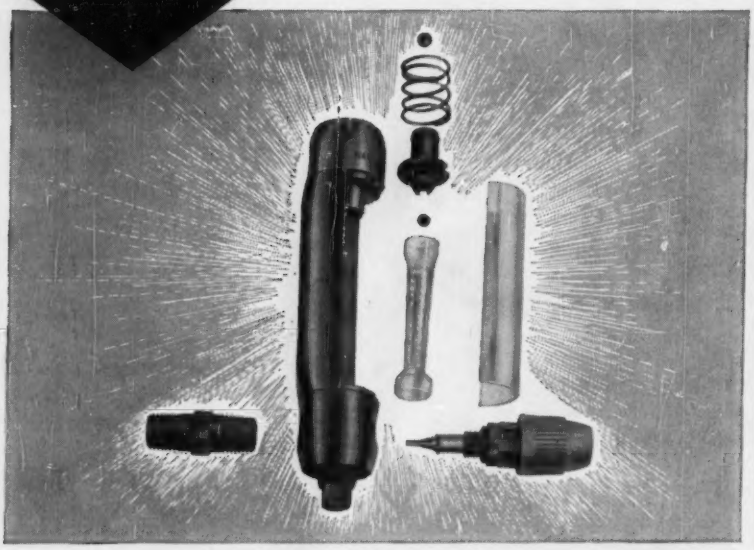
Although we have only touched on the highlights of this phase of mixer corrosion, we hope this will be a stimulus for further development of information.

This is the last of the series on corrosion-control design. For a list of previous articles published this year, see p. 112.

Illustration Credits

Fig. 1—Mixco; Fig. 2—Turbo Mixer; Fig. 3—Nettco; Fig. 6—Mixco—Fig. 7—Chemineer; Fig. 8—Chemineer; Fig. 9—Turbo Mixer.

NOW *fresh design approach gives* THE PURGE METER YOU INSTALL AND FORGET*



It's the new Wallace & Tiernan Varea-meter designed for long, maintenance-free life. Install it and relax . . . forget maintenance headaches.

The Varea-meter's all-stainless, unitized frame shrugs off pipe strains, resists corrosion. There are no small screws or bolts to "freeze"; "O"-rings give permanent, leak-tight sealing. And the Varea-meter's stainless spring really lasts. It's positioned outside the flow stream . . . locks the tube in place externally.

For truer flow indication, a new high-stability float assures foolproof measurement. And for extra convenience, control valve may be placed at the inlet or outlet.

For economy, W&T Varea-meters convert for increased or changed flows with the meter right in the line. And 90% of all parts are interchangeable whether the scale length is 1½" or 3".

There are 29 tube capacities for both scales. Maximum flows for both are 40 gph of water, 110 scfh of air.

Full details and easy-to-order form are ready now. Write Dept. V-1.29.

WALLACE & TIERNAN INCORPORATED

25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

CPI NEWS BRIEFS . . .

(continued from page 48)

resenting the first atomic power facility in the Southeast, it will consist of a 17,000-kw. generating station powered by a reactor that uses heavy water as both coolant and moderator. Facility will feature pressure tubes installed in a relatively low-pressure tank—in place of the usual heavy steel vessel—to house the reactor core and its structural supports. Plant is scheduled for completion in mid-1962. Development and design of the reactor is by Westinghouse Electric Corp.; over-all engineering for the plant is being furnished by Stone & Webster Engineering Corp.

Texas Gas Transmission Corp. has filed an application with the Federal Power Commission for authority to build new facilities totalling about $16.8 million in 1961. Projects listed include 146 mi. of new pipeline and 4,000 hp. of compressor capacity to serve customers from Arkansas to Ohio.

Chas. Pfizer & Co., Inc., recently dedicated a new scientific research center at Groton, Conn. Shown above, the center houses some 400 scientists, technicians and supporting personnel. It replaces macrobiological, chemical and biochemical research facilities that were located for the most part at the company's laboratories in Brooklyn, N. Y. The new building contains 177,000 sq. ft., occupies a 19-acre site.

Trans-Jeff Chemical Corp., a joint venture of Transcontinental Gas Pipe Line Corp., Houston, and Jefferson Lake Sulfur Co., New Orleans, has gone on stream with a new sulfur recovery plant. Located near Tilden, Tex., the facility treats an acid gas stream that is extracted by Transcontinental from sour gas.

Shell Development Co. has completed a multimillion-dollar expansion program at its Emeryville Research Center, Emeryville, Calif. During the five years of the program, available space for offices, laboratories and other facilities has been nearly doubled. The center is used for research in both oils and chemicals.

A. O. Smith Corp., Milwaukee, plans to build a $2-million research center near Middleton, Wis. Scheduled for completion in the middle of next year, it will house the 50 scientists who work in the firm's advanced research department. Among the projects to be studied at the new facility are methods for conversion and storage of energy, including solar energy, and use of magnetic materials in computers and other electronic systems. A major reason for selection of the Middleton site is its nearness to the U. of Wisconsin, at Madison.

Offices

Stauffer Chemical Co. has opened a sales office in Wilmington, Del. It will serve the firm's Industrial Chemicals Div. and Victor Div. as sales headquarters for the Wilmington-Philadelphia area.

American Cyanamid Co. announces that the headquarters offices of its Petrochemicals Dept. have been relocated from New York City to Bound Brook, N. J. Company plans to establish the over-all headquarters of its Organic Chemicals Div. at Bound Brook by about mid-1961, and the recent relocation is the first step towards that end.

Miller-Stephenson Chemical Co., Inc., South Norwalk, Conn., a distributor and producer of epoxy products, polyester resins and other materials, is opening a sales office and warehouse in Boston.

Posen & Kline Tube Co., subsidiary of **Handy & Harman,** has opened a Midwest branch office in Chicago. Firm's products include stainless steel and nickel-alloy tubing in seamless and redrawn welded types.

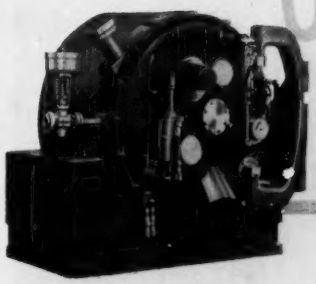
Companies

Continental Oil Co. has purchased three underground caverns from Petroleum Sales, Inc., Lake Charles, La., for storage of propane and butane. Located near Easton, La., they have a total LPG capacity of over 14 million gal. The purchase also included equipment for loading and unloading railroad cars and trucks, as well as other related aboveground facilities. Total price was about $350,000.

An-Cor Industrial Plastics Inc. is a newly formed company that will produce fiberglass-reinforced plastics products for various industries. Affiliated with the Arrow Tank Co., the new firm will have its offices at Arrow Tank's headquarters in Buffalo. To house manufacturing facilities, An-Cor has leased space formerly occupied by a Sylvania Electric Products Inc. plant at Buffalo's Riverside Industrial Center.

Universal Oil Products Co., Des Plaines, Ill., has purchased Catalytic Combustion Corp., Detroit, for UOP stock valued at about $500,000. UOP is a research and process development company in the petroleum and chemical fields; Catalytic Combustion specializes in manufacture and sale of catalytic oxidation equipment for industrial heating and air-pollution control.

Socony Mobil Oil Co., Inc., is forming a new operating division, Mobil Petroleum Co., which will be responsible for Socony's business interests in the Far East, Australia, and eastern and southern Africa. This announcement follows a recent agreement under which the assets of Standard-Vacuum Oil Co., owned jointly by Socony and Standard Oil Co.



SHARPLES

Extreme Dryness, High Purity, of Fine, Compressible Solids

The Sharples C-41 Super-D-Hydrator—the high speed completely automatic perforate basket centrifuge—operates continuously at high speed for recovery, washing and dehydration of crystals and fine, compressible solids. High purity of product is the result of high centrifugal force applied continuously in precisely controlled process steps. 3 different sizes, for operation under vacuum, at normal atmospheric pressure, or at pressures to 150 psig. Write for Bulletin 1286.

THE SHARPLES CORPORATION

2300 WESTMORELAND ST., PHILA. 40, PA.

Manually variable microflex

CHEMICAL PROPORTIONING PUMPS

give trouble-free service

24 HOURS A DAY

at rated pressures up to

60,000 p.s.i.,

for as long as

EIGHTEEN MONTHS

without a major overhaul

Heavy duty pumps that provide rugged, reliable, round-the-clock operation under the most severe chemical plant conditions. They handle virtually any chemical fluid, at pressures up to 60,000 p.s.i. and capacities up to 31 gallons per hour.

Especially important is the design feature that completely evacuates the pumping cylinder at each stroke of the piston, irrespective of stroke length. This factor promotes efficient pumping for all types of fluids, even those which are highly compressible. Also important is the fact that piston stroke can be varied during pump operation, from 0 to 100%.

SPECIAL FEATURES include: interchangeability of piston and cylinder assemblies in framework housing, to permit change in capacities and pressure ratings . . . use of an external check valve with inlet and outlet connections for fluids to be pumped; this location permits easy removal for service or replacement . . . piston-cylinder assemblies are made of stainless steel; Hastelloy, Monel, or other alloys for special applications. Simplex and duplex models are offered as standard; triplex and quadruplex on special order.

Complete details and technical data in Catalog 460-C forwarded on request.

AMINCO

AMERICAN INSTRUMENT CO., INC. 8030 Georgia Ave., Silver Spring, Maryland

(N. J.), will be divided between the two owner firms.

Bemis Bro. Bag Co., St. Louis, has acquired a substantial interest in The Systemation Corp., a Chesterfield, Mo., firm that specializes in developing integrated and automatic packaging systems and machinery.

Astropower, Inc., is a new subsidiary corporation formed by Douglas Aircraft Co., Inc., Santa Monica, Calif., to conduct advanced research on propulsion systems for space vehicles. It is an outgrowth of a former corporation named Aero-Space Technology, Inc., and Aero-Space's founders will continue as executives of the subsidiary for Douglas. Propulsion systems to be studied will include ones from nuclear, chemical and electrical fields.

Stauffer Metals Co. is the new name of the former Stauffer-Temescal Co., which was formed to develop an electron-beam melting process for metallurgical use. Currently a wholly owned subsidiary of Stauffer Chemical Co., New York, it will become a division of Stauffer on January 1, 1961.

International

Canada: Columbia Hardboard Co., Seattle, will build a $3-million plant at Sprague, Man., to produce particle board. Differing from hardboard or fiberboard in that it is made from flakes or particles of wood glued together with a resin binder, the particle board product will be sold largely to furniture and construction firms. Output will be 10 million sq. ft./yr., and the basic raw material will be poplar.

Wales: Forth Chemicals, said to be England's largest polystyrene producer, plans to build a 50,000-ton/yr. styrene monomer plant between Neath and Port Talbot in south Wales. Cost will be over $8.4 million. Facility will be designed and engineered by Monsanto Chemical

Co., which owns one third of Forth Chemicals. It is expected to go on stream by the end of 1962, treating feedstock from British Petroleum's nearby refinery at Llandarcy.

Northern Ireland: The British Petroleum Co. will build an oil refinery—Northern Ireland's first—at Belfast. Initial capacity will be 30,000 bbl./day, and the facility will turn out gasoline, kerosene, aviation turbine fuels, light and heavy diesel oils, fuel oil and LPG. Project will require about two years to complete, will involve an initial investment of about $22.4 million.

Canada: The International Nickel Co. of Canada, Ltd., will triple capacity of its iron ore recovery plant at Copper Cliff, Ont. Expanded plant is scheduled to go into full operation in 1963, treating 1.2 million short tons/yr. of high-iron-content nickeliferous pyrrhotite. Company will spend up to $10 million on the expansion during 1961.

England: British Celanese Ltd., subsidiary of Courtaulds Ltd., London, has started constructing an aromatics condensate separation unit at its chemical plant in Spondon, Derbyshire. It is due to go on stream in August, 1961, producing nitration grades of benzene and toluene, as well as xylene. Included in the facility will be a cyclopentadiene recovery unit.

Canada: Construction is starting on a $13-million gas processing and sulfur recovery plant near Calgary, Alta., which will be jointly owned by Jefferson Lake Petrochemical Co. and Mobil Oil of Canada Ltd. Annual production will be about 285,000 tons sulfur, 700,000 bbl. condensates and 36.5 billion cu. ft. pipeline gas. Facility is scheduled to start operating next November, is being constructed by Ralph M. Parsons Co., Los Angeles.

Argentina: B. F. Goodrich Chemical Co., Cleveland, and R. T. Vanderbilt Co., Inc., New York, are entering into a joint venture with the Argentine chemical firm Atanor S.A.M. for manufacture of rubber chemicals, including accelerators and antioxidants. It is planned to locate the required production facilities near Buenos Aires; during their construction, interim production will be carried out in existing Atanor facilities.

Canada: Canadian Oil Companies Ltd. has announced a $750,000 expansion program to double benzene production at the firm's petrochemical manufacturing facilities in Sarnia, Ont. A Hydeal unit for converting toluene to benzene will be constructed as part of the project; it is due to go on stream in June. Expanded benzene production level will be 7 million gal./yr.

Jamaica: Brandram-Henderson Ltd., Montreal, Can., will build a paint manufacturing plant in Kingston, Jamaica. Scheduled to start up early in 1961, it will have initial annual capacity of 150,000 U.S. gal.

Japan: A new Japanese company, Showa Neoprene K.K., is being formed jointly by E. I. du Pont de Nemours & Co., Wilmington, Del., and Showa Denko K.K., Tokyo, to manufacture and sell neoprene synthetic rubber. It will operate an 18-million-lb./yr. plant that will be built probably at Kawasaki.

Canada: Three developments involving Canada's oil and natural gas industries have recently been announced: (1) Shell Oil Co. plans to build a $20-million gas processing plant at Pincher Creek, Alta. Daily capacity will be 100 million cu. ft. processed gases, 1,000 tons sulfur and up to 4,000 bbl. condensates. (2) The British Petroleum Group has gone on stream with a $45-million refinery near Montreal. Representing Canada's newest refinery and BP's first refinery in the Western Hemisphere, the facility can handle over 25,000 bbl./day crude oil. (3) Crude running capacity of British American Oil Co. Ltd.'s refinery at Calgary has been increased from 7,500 to 10,000 bbl./stream day, as the result of a $1.5-million expansion and modernization program.

SHARPLES

Dewater Up to 70 tons/hr Choice of 4 Standard Sizes

The Sharples Super Conejector effectively deliquefies process feeds containing high concentration of medium-to-coarse crystalline solids, as well as fibrous pulps—at production rates up to 70 tons/hr and more. 4 standard sizes are available to meet the wide range of individual requirements in the chemical and food industries.

THE SHARPLES CORPORATION

2300 WESTMORELAND ST., PHILA. 40, PA.

Which valve alloy?

Corrosion testing, which often includes analysis of test specimens like those shown above, insure Aloyco valve customers of the right alloy for each job. Typical metals used in Aloyco Valves: Types 304 and 316 Stainless Steel, Aloyco 20, Nickel, Monel, Hastelloy B, C and D.

At Aloyco, 30 years experience in stainless steel valves exclusively is at your service. Our field consulting service is yours for the asking.

On your next valve job call in the specialists . . . write Alloy Steel Products Company, 1327 West Elizabeth Avenue, Linden, New Jersey. 9.14

ALLOY STEEL PRODUCTS COMPANY
Linden, New Jersey

Convention Calendar

December

26-31. American Assn. for the Advancement of Science, Annual Meeting, New York, N. Y.

27-30. Case Institute of Technology, Society for the History of Technology, 1960 Meeting, New York, N. Y.

29-30. American Chemical Society, 27th Annual Chemical Engineering Symposium of the Division of Industrial and Engineering Chemistry, Washington University, St. Louis, Mo.

January

16-18. American Astronautical Society, 7th Annual Meeting and Convention, Sheraton-Dallas Hotel, Dallas.

17-19. Instrument Society of America, Winter Instrument-Automation Conference and Exhibit, Sheraton-Jefferson Hotel and Kiel Auditorium, St. Louis, Mo.

23-26. 12th Annual Plant Maintenance & Engineering Show, International Amphitheatre, Chicago, Ill.

24-27. Society of Plastics Engineers, Annual Technical Conference, Shoreham and Park-Sheraton Hotels, Washington, D. C.

24-27. Canadian Pulp and Paper Assn., 1961 Annual Meeting of the Technical Section, Queen Elizabeth Hotel, Montreal, Que.

30-9. University of Illinois, Quality Control by Statistical Methods, Urbana, Ill.

February

5-10. National Petroleum Assn., Symposium on Research on Gasoline, Benjamin Franklin Hotel, Philadelphia, Pa.

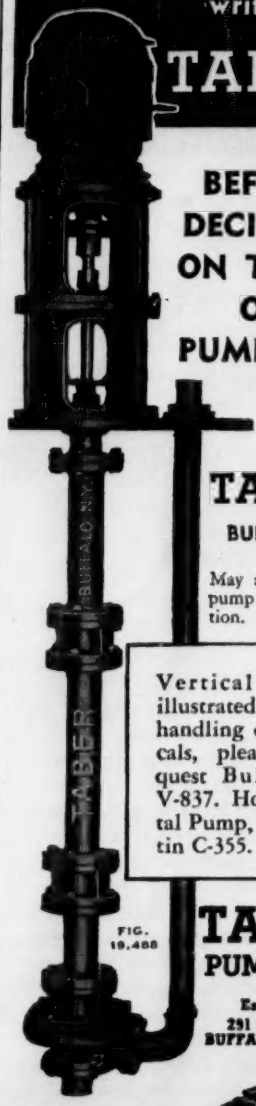
7-9. The Society of the Plastics Industry, Inc., 16th Reinforced Plastics Division Conference, Edgewater Beach Hotel, Chicago, Ill.

13-16. American Society of Heating, Refrigerating and Air-Conditioning Engineers, 15th International Heating & Air-Conditioning Exposition, Chicago Amphitheatre, Chicago, Ill.

13-17. American Management Assn., Inc., Packaging Management Course, Hotel Astor, New York, N. Y.

16-17. American Society for Metals (Albuquerque and Los Alamos Chapters), Symposium on Recent Develop-

PUMP PROBLEMS
write
TABER



BEFORE DECIDING ON TYPE OF PUMPS . . .

SEE TABER BULLETINS

May avoid costly pump misapplication.

Vertical pump illustrated, for handling chemicals, please request Bulletin V-837. Horizontal Pump, Bulletin C-355.

FIG. 19.488

TABER PUMP CO.
Est. 1859
291 ELM ST.
BUFFALO 3, N. Y.

TABER

ECONOMICAL COOLING OF GASES and COMPRESSED AIR

NIAGARA *Aero* AFTER COOLERS

● Cooling gases or cooling and removing moisture from compressed air, the Niagara *Aero* After Cooler offers the most economical and trustworthy method. Cooling by evaporation in a closed system, it brings the gas or compressed air to a point close to the ambient temperature, effectively preventing further condensation of moisture in the air lines. It is a self-contained system, independent of any large cooling water supply, solving the problems of water supply and disposal.

Cooling-water savings and power-cost savings in operation return your equipment costs in less than two years. New sectional design reduces the first cost, saves you much money in freight and installation labor and in the expense of upkeep.

Niagara *Aero* After Cooler systems have proven most successful in large plant power and process installations and in air and gas liquefaction applications.

Write for Descriptive Bulletin 130

NIAGARA BLOWER COMPANY

Dept. CE-12, 405 Lexington Ave.
NEW YORK 17, N. Y.
District Engineers in Principal Cities of U. S. and Canada

ments in Materials for Nuclear Applications, University of New Mexico, Albuquerque, N. M.

20-23. Technical Assn. of the Pulp and Paper Industry, 46th Annual Meeting, Hotel Commodore, New York, N. Y.

26-1. American Institute of Chemical Engineers, Petroleum and Petrochemical Exposition, National Meeting, Municipal Auditorium, New Orleans, La.

26-2. Society of Petroleum Engineers of the American Institute of Mechanical Engineers, Annual Meeting, Chase & Park Plaza Hotels, St. Louis, Mo.

March

5-9. The American Society of Mechanical Engineers and The U. S. Department of Defense, 6th Annual Gas Turbine Conference and Products Show, Shoreham Hotel and Pentagon, Washington, D. C.

13-17. National Assn. of Corrosion Engineers, Annual Conference & Corrosion Show, Statler Hotel, Buffalo, N. Y.

15-17. Natural Gasoline Assn. of America, 40th Annual Convention, Baker Hotel, Dallas, Tex.

20-24. American Society of Metals, 12th Western Metal Congress, Ambassadore Hotel, and Western Metal Exposition, Pan-Pacific Auditorium, Los Angeles, Calif.

21-23. Illinois Institute of Technology and American Society of Mechanical Engineers, American Power Conference, Sherman Hotel, Chicago, Ill.

27-29. Midwest Gas Assn., Annual Meeting & Convention, Sheraton-Fontenelle Hotel, Omaha, Neb.

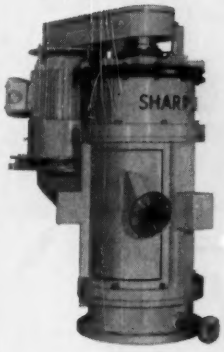
27-31. American Institute of Physics, Instrument Society of America, and National Bureau of Standards, 1961 Symposium on Temperature, Its Measurement and Control in Science and Industry, Columbus, Ohio

April

6-7. American Society of Mechanical Engineers, Management Engineering Conference, Statler-Hilton Hotel, New York, N. Y.

10-11. American Society of Mechanical Engineers, Maintenance & Plant Engineering Conference, Bancroft Hotel, Worcester, Mass.

10-11. The Combustion Institute, Western States Section, 1961 Spring Meeting, Aeronutronic, Newport Beach, Calif.



SHARPLES

Continuous Dewatering of Non-Filterable Slurries, Complete Range of Capacities

The line of Sharples Super-D-Canters will continuously process slurries with a wide range of solids concentration—½% to 50%—at broad range of capacities. The exclusive vertical Super-D-Canter provides operation under vacuum or at pressures to 150 psig.

THE SHARPLES CORPORATION

2300 WESTMORELAND ST., PHILA. 40, PA.

Tighten Down on FOAM

with Dow Corning Silicone Defoamers*

There's a *right* tool for every job. In foam control it's Dow Corning silicone antifoamers or defoamers . . . job-proved thousands of times over as the most efficient, most economical, and most versatile foam suppressors available.

*At prescribed levels, are sanctioned by FDA

FREE SAMPLE
and new manual on foam control

first in silicones
Dow Corning CORPORATION
MIDLAND, MICHIGAN

Dept. 1812a

Please rush a FREE SAMPLE of a Dow Corning silicone defoamer for my product or process, which is (indicate if food, aqueous, oil or other): ----------

NAME

POSITION

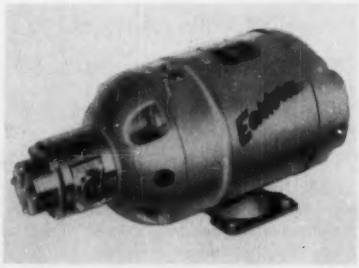
COMPANY

ADDRESS

continued from page 70)

lation and effective stripping, contains a built-in oil separator and a liquid condenser. Moisture measurement system contains a bypass that assures minimum sample holdup, has a sample and bypass flow meter. In third module, moisture in fluid is measured, then indicated or recorded.

Different models are used for pressures above and below 4 psi. A portable model is said to measure moisture concentrations down to less than 1 ppm. New unit is particularly suitable for measuring moisture content of refrigerant gases, of industrial process streams and in natural gas transmission systems.—**Manufacturers Engineering & Equipment Co., Hatboro, Pa.** **70D**



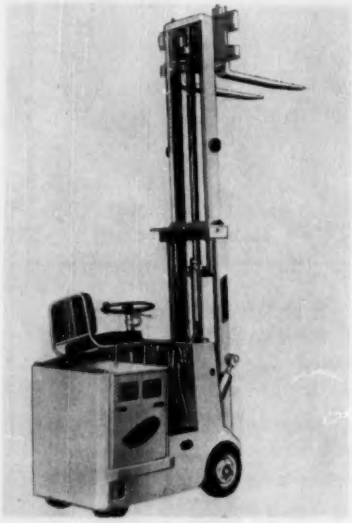
Self-priming vane pump

Positive-displacement type unit handles nonlubricating liquids.

Composition graphite bearings and vanes—plus the absence of metal-to-metal contacts—account for the ability of a new positive-displacement pump to handle nonlubricating liquids with no lubrication beyond that of the liquid being pumped.

Said to be self-priming, the new pump is available in bronze with adjustable bypass, or in stainless steel construction without bypass, including stainless steel rotor, composition bearing and mechanical seal.

Designated VW-20, it pressures liquids with specific gravities similar to water to 60 psi., has maximum flow of 60 gpm. Furnished with motors in close-coupled units, it is also available for belt, coupling drive.—**Eastern Industries, Inc., Hamden, Conn.** **124A**



Electric truck

Unit has short turning radius, is efficient in narrow aisles.

A new electric industrial truck is designed with a short turning radius for maximum efficiency in narrow-aisle operations. It has a 2,000 lb. capacity for up to 48-in. long loads.

Standard features include worm drive, twin-tilt cylinders, hydraulic wheel brakes and safety controls. Operating controls are of the automotive type, operated from a normal driving position.

A 3,000-lb. model is also available.—**The Elwell-Parker Electric Co., Cleveland.** **124B**

Impact tools

Detachable torsion bars give a variety of precise torques.

To drive nuts, bolts and cap screws to a variety of precise torques, a new impact tool features detachable torsions bars. To

The FALCON RIBBON BLENDER

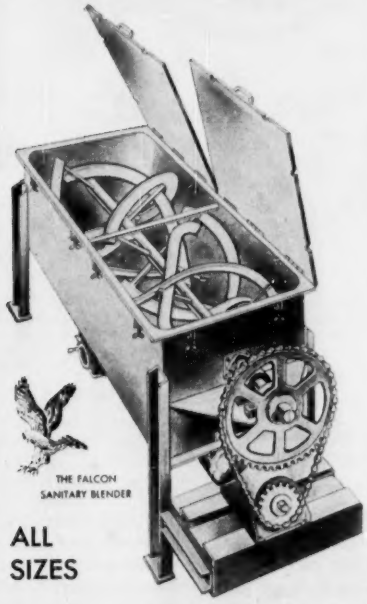
"the TOP-FLIGHT Mixer"

- POWER
- PRODUCTION
- PRICE

FEATURES . . .

- *All Welded Construction*
- *Mild Steel or Stainless*
- *Approved Sanitary Design*
- *All Rounded Corners Thruout*
- *Quickly Demounted for Cleaning*
- *Extra Heavy Shafts and Ribbons*
- *Leak Proof-Dust Tight Outlet*
- *All Sizes Usually in Stock*

MANY REPEAT ORDERS FROM PLANTS NOW USING FALCON MIXERS



ALL SIZES

Send for Brochure

THE FALCON MANUFACTURING DIVISION

OF THE

FIRST MACHINERY CORP.

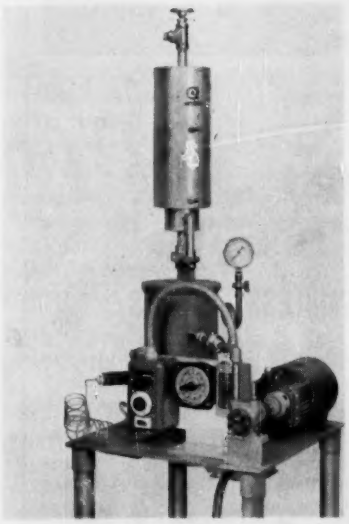
209-289 TENTH STREET,
BROOKLYN 15, N. Y.
PHONE: STerling 8-4672

change the torque delivered by the tool, the operator simply snaps on a different preset torsion bar as easily as changing sockets.

Called Impactool, device shuts off automatically when the preset torque of the torsion bar is reached. Torque mechanism automatically resets for the next operation as soon as the tool's trigger is released.

The tool is said to operate quietly because exhaust air passes through three expansion chambers in special muffler. Either the motor or the impact mechanism can be serviced separately without disturbing the other.

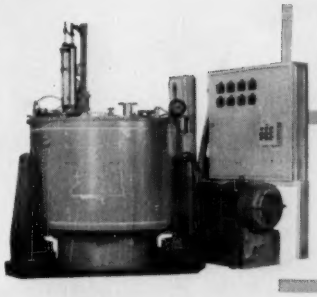
Impactool comes in two models, each with heavy and light torsion bars. Larger unit's bars range from 20 to 50, 45-90 ft.-lb. Smaller tool covers the range from 6-17, 10-30 ft.-lb.—**Ingersoll-Rand, New York.** 124C



Evaporator-stripper

Chlorinated and fluorinated hydrocarbons are recovered.

A high rate of solvent recovery on a continuous basis is one feature of a new evaporator-stripper designed for the recovery of chlorinated and fluorinated hydrocarbons. New model, of 2.5-gph. capacity, joins line that includes



"Nurture" Fragile Crystals at High Production

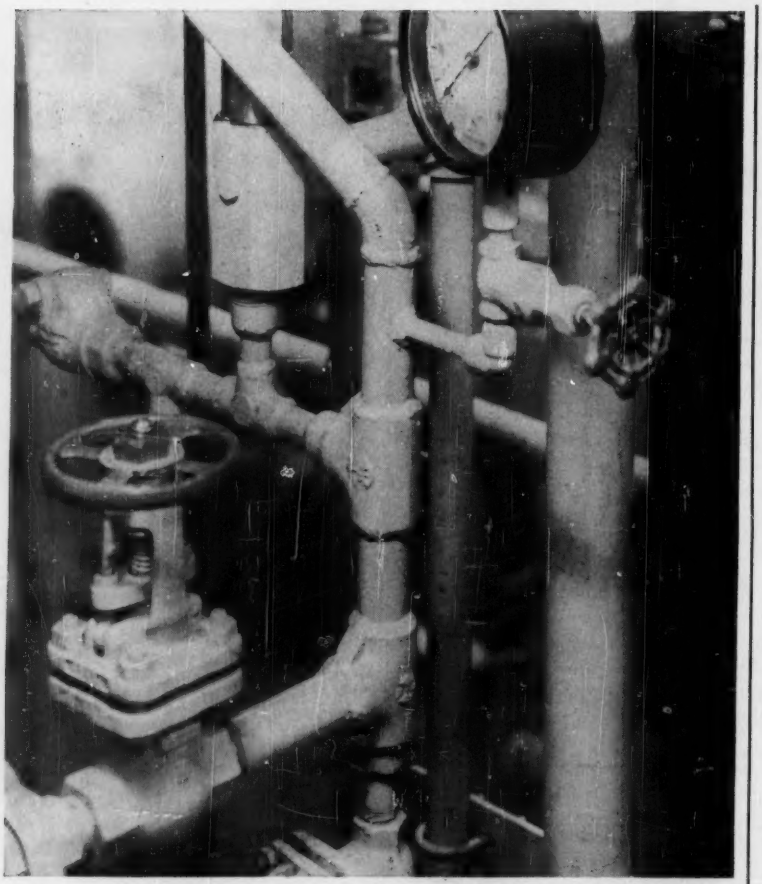
The batch-type Sharples-Fletcher Tornado-Matic deliquefies fragile crystals —and a wide variety of fine-to-coarse solids at high production—with constant uniformity of processing and product purity. All cycle steps are fully automatic. Write for Bulletin 202-560.

SHARPLES

the FLETCHER division of

THE SHARPLES CORPORATION

2300 WESTMORELAND ST., PHILA. 40, PA.



Forged stainless steel 150 lb. socket weld W-S Fittings on tank piping at E. R. Squibb & Sons plant, New Brunswick, N. J.

To Beat Corrosion's Bite

—W-S FORGED 150 LB. STAINLESS FITTINGS

They're ideal for standard pressure services (300 p.s.i. cold, non-shock and 150 p.s.i. steam pressure) requiring corrosion resistance or toughness at low temperatures.

But maybe your next installations call for forged aluminum fittings, or forged carbon steel fittings, or forged stainless and alloy fittings for higher pressures. W-S specializes in designing and making them all to top standards of safety and high strength . . . with outstanding resistance to shock, heat, vibration.

For specifications and distributor locations, write *Forge & Fittings Division, H. K. Porter Company, Inc., Box 95, Roselle, N. J.*

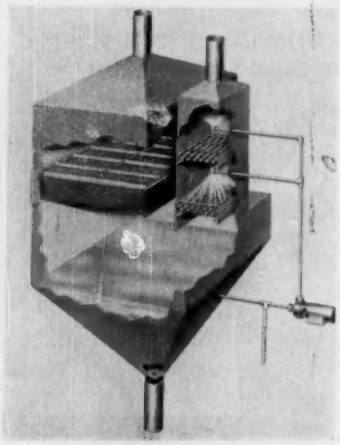
FORGE AND PORTER **FITTINGS DIVISION**

H. K. PORTER COMPANY, INC.

PORTER SERVES INDUSTRY with steel, rubber and friction products, asbestos textiles, high voltage electrical equipment, electrical wire and cable, wiring systems, motors, fans, blowers, specialty alloys, paints, refractories, tools, forgings and pipe fittings, roll formings and stampings, wire rope and strand.

smaller as well as larger units to 100 gph. and more.

Recoveries to 98% are easily obtained, according to the manufacturer; using stripping steam, recoveries can be raised to 99.9%. Unit is available with either electricity or steam for energy source. Basic price of $500 includes evaporator, stripper, condenser and electric heater. Parts in contact with overhead vapor and condensate are Type 316 stainless steel.—**Artisan Metal Products, Waltham, Mass.** 125A



Air scrubber

Six-stage scrubbing action captures dust particles.

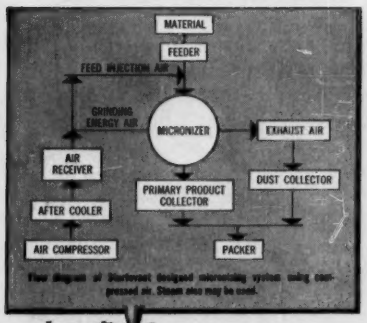
A new air scrubber removes dust particles from flowing gas streams in six distinct stages without any moving parts, using watersprays, screening and particle momentum at various points in the apparatus.

Dusty air, introduced by blower into the unit, is countercurrently water sprayed to encapsulate dust particles, then passed through round screening rods—in staggered arrangement—that provide impingement surface to further wet the dust. Downstream turbulence beyond the rods further aids dust-water contact.

The gas stream then passes through a second water stream and penetrates a bank of triangular rods designed to cause

Need ½ to 44 Microns?

Sturtevant Micronizers* Make 325 Mesh Obsolete



Flow diagram of Sturtevant designed micronizing system using compressed air. Steam also may be used.

Production Model (15 in. chamber)

One Operation Reduces, Classifies

Sturtevant Micronizers grind and classify in one operation in a single chamber—provide fines in range from ½ to 44 microns to meet today's increased product fineness needs. Can handle heat-sensitive materials.

No Attritional Heat

Particles in high speed rotation, propelled by compressed air entering shallow chamber at angles to periphery, grind each other by violent impact. Design gives instant accessibility, easy cleaning. No moving parts.

Classifying is Simultaneous

Centrifugal force keeps oversize material in grinding zone, cyclone action in central section of chamber classifies and collects fines for bagging. Rate of feed and pressure control particle size.

Eight Models Available

Grinding chambers range from 2 in. diameter laboratory size (½ to 1 lb. per hr. capacity) to large 36 in. diameter production size (500 to 4000 lbs. per hr. capacity). For full description, request Bulletin No. 091.

Engineered for Special Needs

A 30 in. Sturtevant Micronizer is reducing titanium dioxide to under 1 micron at feed rate of 2250 lbs. per hr. For another firm, a 24 in. model grinds 50% DDT to 3.5 average microns at a solid feed rate of 1200-1400 lbs. per hr. A pharmaceutical house uses an 8 in. model to produce procaine-penicillin fines in the 5 to 20 micron range. Iron oxide pigment is being reduced by a 30 in. Micronizer to 2 to 3 average microns.

Sturtevant will help you plan a Fluid-Jet system for your ultra-fine grinding and classifying requirements. Write today.

Can Test or Contract Micronizing Help You?

Test micronizing of your own material, or production micronizing on contract basis, are part of Sturtevant service. See for yourself the improvement ultra-fine grinding can contribute to your product. Write for full details. STURTEVANT MILL CO., 100 Clayton St., Boston, Mass.

*REGISTERED TRADEMARK OF STURTEVANT MILL CO.

even micron-sized particles to impinge upon passage through them. Downstream turbulence from these rods completes the scrubbing action.

Before going through a final filter, the stream is conducted via a baffle through a 180-deg. turn that causes wetted particles to drop out into a tank from which they can be withdrawn. According to the manufacturer, water consumption may be as little as 1 gpm./1,000 cfm. of gas.—**Antipol Corp., Galesburg, Ill.** 126A

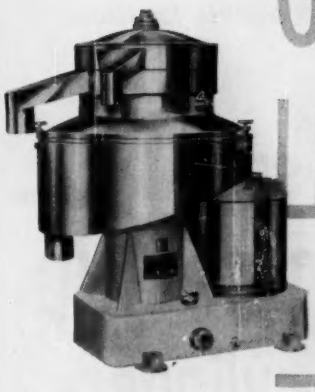
Briefs

Pipe dope in tape form, called Pipe-Pac is now available for making up threaded joints in all types of pipe—metal, plastic, ceramic or rubber. It will withstand temperatures from −300 to +500 F., can be used in almost any gas or liquid service. — **Johns-Manville Corp., New York.** 127A

Radiation slide rule permits one-step calculation of information relating to radiation from a black body. Direct reading of values in both watts and photons/sq. cm. are given. Twin temperature scales in degrees C. or K. provide a range from −180 to +10,000 C.—**Walsh Engineering Sales Co., Inglewood, Calif.** 127B

Drain valve is extremely corrosion resistant since all internals are machined from impervious graphite. Valve uses a piston closure, without seats, that protects it against overtightening. It is available in 2-, 3-, 4- and 6-in. sizes for temperatures to 340 F., pressures to 150 psi.—**Falls Industries, Inc., Solon, Ohio** 127C

Relief valve handles corrosive fluids safely because body is made of polyvinyl chloride. Spring-loaded, diaphragm-actuated valve modulates in response to upstream pressure. Sized up to 2 in., valve withstands 160 F.—**Atlas Valve Co., Newark, N. J.** 127D



SHARPLES

Continuous Solids Discharge, Effective Clarification of Liquids

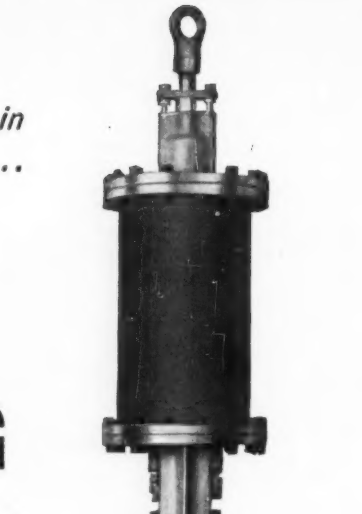
The Sharples Nozljector centrifuge performs highly efficient clarification of liquids containing a relatively high proportion of solids, concentration of solids from a slurry, or separation of two immiscible liquids. A wide variety of models and drives are available to meet individual capacity and process requirements. Write for Bulletin 1285.

THE SHARPLES CORPORATION

2300 WESTMORELAND ST., PHILA. 40, PA.

For frequent operation in inaccessible locations...

specify DARLING cylinder-operated GATE VALVES



Here's a valve that's as versatile as you want to make it. It can be readily adapted to your piping conditions or process cycles. For example:

Manual or Automatic Operation may be used—by means of four-way valves which control the flow of fluid or air to the cylinders.

Air, Oil or Water may be used for the operating media—and can be piped from the lines on which the valves are installed.

Engineered for Your Application—Valves can be supplied, piped and equipped with solenoid or pilot-operated control valves, limit switches and positioners for remote or local operation.

Write for detailed information or quotes, giving size of valves required, kind of valves (Iron Body Bronze Mounted, All-Iron, Bronze, Special Alloy, etc.), service conditions, maximum disc pressure and minimum cylinder pressure.

DARLING VALVES

DARLING VALVE & MANUFACTURING CO.

Williamsport 3, Pa.

Manufactured in Canada by Canada Valve & Hydrant Co., Ltd., Brantford, Ont.

NEW EQUIPMENT . . .

Air sampler collects dusts and aerosols in air at rates to 200 cfm., or twice the rate of previous instruments. Accuracy of flow measurement is obtained with a dial-reading orifice gage. Filter holder with 4-in.-dia. filter can be quickly changed in field.—**Gelman Instrument Co., Chelsea, Mich.** 128A

Vibration monitor protects equipment and processes against excess vibration. Sensitive to vibrations as small as 0.000002-in. amplitude, it can flash a signal or stop the offending machinery. Level of vibration that sets off the monitor can be adjusted. Monitor can also be set to filter out extraneous vibrations, pick only those for which it is preset.—**Stewart-Warner Corp., Chicago.** 128B

Safety switch protects machines and equipment against damage resulting from stoppage of other equipment. Switch may control a motor circuit or operate a warning device, can be connected to any machinery with rotating parts.—**Fuller Co., Catasaqua, Pa.** 128C

Equipment Cost Indexes . . .

	June 1960	Sept. 1960
Industry		
Avg. of all	238.2	237.4
Process Industries		
Cement mfg.	232.8	231.7
Chemical	240.1	238.6
Clay products	226.2	225.6
Glass mfg.	226.6	225.3
Paint mfg.	229.8	229.1
Paper mfg.	231.3	229.9
Petroleum ind.	234.1	234.0
Rubber ind.	237.6	236.9
Process ind. avg.	236.5	236.2
Related Industries		
Elec. Power equip.	242.7	240.2
Mining, milling	241.5	240.0
Refrigerating	268.5	267.7
Steam power	225.0	224.3

Compiled quarterly by Marshall and Stevens, Inc. of Ill., Chicago, for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124–6 for method of obtaining index numbers; April 4, 1960, pp. 149-50 for annual averages since 1913.

Technical Bookshelf

OLD FAITHFUL, NEW EDITION

HANDBOOK OF CHEMISTRY AND PHYSICS. 42nd ed. Ed. by C. D. Hodgman; and R. C. Weast and S. M. Selby. The Chemical Rubber Publishing Co., 2310 Superior Ave. N.E., Cleveland 14, Ohio. 3,481 pages. $12 in U.S., $12.50 elsewhere.

Latest edition of this desk classic continues to revise and expand the subject material. As listed, new data are included on: atomic weights, electronic configuration of the elements, trade names of plastics, analytical reagents, volumetric primary standards, efficiency drying agents, properties of refractory materials, nuclear spins, definitions.

More than 20 new tables have been provided, cover such subjects as: standard types of stainless steel, diffusion of metals into metals, surface tension of both organic and inorganic solutes in water, surface tension of both inorganic solutes and organic compounds in organic solvents. Also: miscibility, components of atmospheric air, interplanetary orbits.

In Rapid Review

Advanced Organic Chemistry. 3rd ed. By G. W. Wheland. John Wiley & Sons, New York. 871 pages. $17.50. Organic chemistry has made a complete transition from purely descriptive cataloging to a predictable, physically oriented science. No better example for the modern approach to the physical-organic concepts entailing stereochemistry, conformational analysis, molecular rearrangements and their underlying theories can be found than Dr. Wheland's mature text (now in its 3rd edition). As the dust wrapper correctly states, it "provides a broad base for the structural theory of organic chemistry."

Synthetic Methods of Organic Chemistry. Vol. 14. By W. Theilheimer. Interscience Publishers, New York. 549 pages. $29.50. A record of selected papers, published between 1957 and 1959, is concerned with r thods for the syntheses of organic compounds. The methods are grouped under classified reaction symbols. A chapter on trends in synthetic organic chemistry is based on selected papers published in 1959 and 1960.

Non-Crystalline Solids. Ed. by V. D. Frechette. John Wiley & Sons, New York. 536 pages. $15. A collection of the papers and discussions presented at the Conference on Non-Crystalline Solids, Alfred, New York, September 3-5, 1958. A notable group of investigators from several fields contributed to the success of the conference. The book is a good introduction to the topic, also offers much new information on an interesting subject.

Additional material received:

Standards of the Hydraulic Institute. 10th ed., 1st rev. Insert pages (75 pp.) update the tenth edition. They clarify and correct the nomenclature, drawings and text; provide new definitions for flooded suction, specific speed, self-priming pumps; revise test code for centrifugal pumps, etc. Hydraulic Institute, 122 E. 42nd St., N. Y. 17, N. Y. Cost: $1.25 for insert; Standards (incl. insert) $6.

Proceedings of the 1959 Computer Applications Symposium. Papers given at the Chicago meeting are presented in a 155-page booklet, include series on (1) business and management applications, (2) engineering and scientific applications. Write: Armour Research Foundation of Illinois Institute of Technology, MF:CA6, 10 West 35th St., Chicago 16, Ill. $3.

The Executive: Philosophy, Problems and Practices. Compiled for the Dept. of the Army, this 39-page bibliography lists recent articles (mostly since 1956) on all phases of management, also gives brief summary of contents of each. Free. Write: Mr. G. L. Ward, Natl. Assn. of Mfrs., 2 East 48th St., N. Y. 17, N. Y.

Funds for Research and Development in Industry, 1957. The National Science Foundation has prepared this rundown on performance and financing of R&D in 1957. The 119-page report is split into two major sections: Part 1—Characteristics of Selected Industries (Section 6 covers chemicals and allied products). Part 2: R&D Characteristics of Selected Industries. For copy (65¢) write: Supt. of Documents, U.S. Govt. Printing Office, Washington 25, D. C.

Sharples—
The Complete
Line of
Centrifuges
For Industry

Let Sharples assist you in the choice of the right centrifuge for your particular requirements. Only Sharples—leader throughout the world in centrifugal skill and equipment—has the complete line of centrifuges for industry, assuring you of an unbiased recommendation.

THE SHARPLES CORPORATION

2300 WESTMORELAND ST., PHILA. 40, PA.

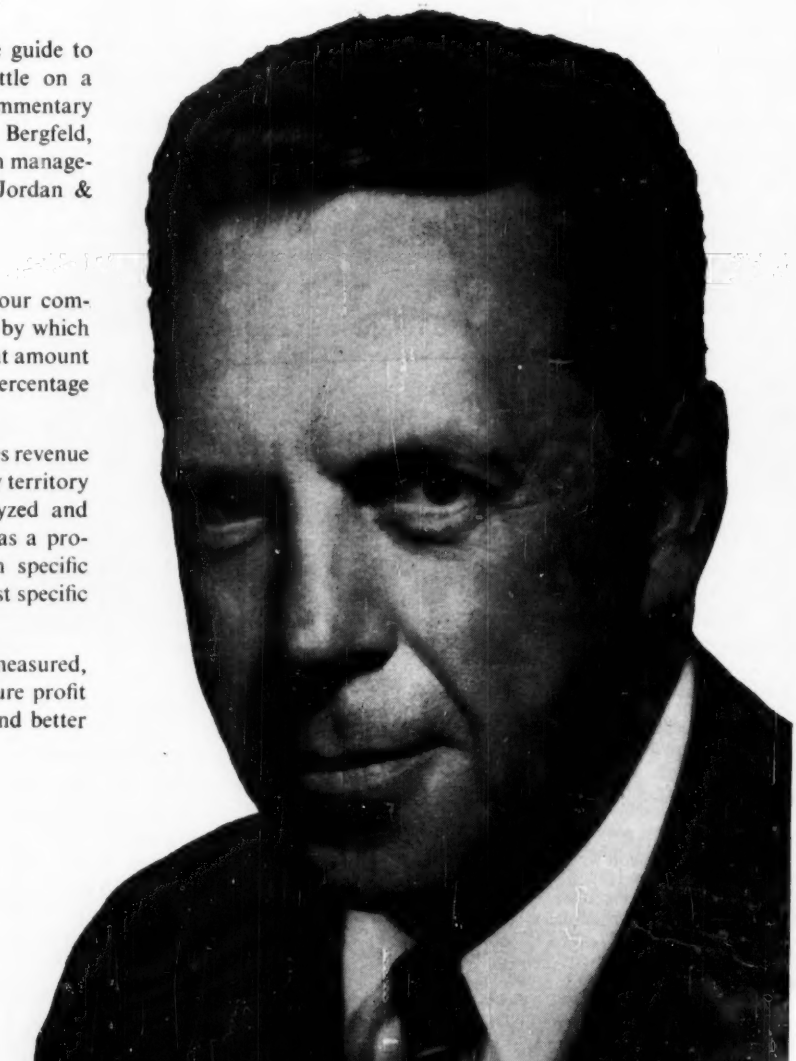
"What's so bad about basing the ad budget on last year's shipments?"

Management men, seeking a reliable guide to advertising appropriations, often settle on a percentage of sales. The following commentary on this practice was written by A. J. Bergfeld, President of the internationally known management consultant firm of Stevenson, Jordan & Harrison, Inc.

"Past practices of your own or of your competitors will produce no magic ratios by which you can either judge or budget the right amount of advertising automatically as a percentage of past sales.

"Plans for increasing sales volume, sales revenue and resulting profits by product and by territory or by divisions, can better be analyzed and approved by considering advertising as a programmed cost to be associated with specific profit plans and to be measured against specific results.

"Programming advertising costs as a measured, reasoned and integrated part of a future profit plan usually results in a better plan and better actual future profits."



AIA

ASSOCIATION OF INDUSTRIAL ADVERTISERS

271 madison avenue • new york 16, n. y. • telephone murray hill 5-8921

An organization of over 4000 members engaged in the advertising and marketing of industrial products, with local chapters in ALBANY, BALTIMORE, BOSTON, BUFFALO, CHICAGO, CLEVELAND, COLUMBUS, DALLAS, DENVER, DETROIT, HAMILTON, ONT., HARTFORD, HOUSTON, INDIANAPOLIS, LOS ANGELES, MILWAUKEE, MINNEAPOLIS, MONTREAL, QUE., NEWARK, NEW YORK, PHILADELPHIA, PHOENIX, PITTSBURGH, PORTLAND, ROCHESTER, ST. LOUIS, SAN FRANCISCO, TORONTO, ONT., TULSA, YOUNGSTOWN.

Letters: Pro & Con

Con: Book Review Format

Sir:

I've never seen such an absurd form for book reviews (Oct. 3, 1960, pp. 150-151). You'll effectively kill off all interest in reviews unless you reform.

IRWIN B. MARGILOFF
New York, N. Y.

Pro: Gifts to Colleges

Sir:

Your industrial readers might not be aware that office and laboratory equipment that they may consider "obsolete" could be of great use to institutions of higher learning.

For example, Colgate University recently received some laboratory balances that had been replaced in a research laboratory by a newer electronic type. For this particular corporation, the old instruments were considered obsolete, but for Colgate they were ideal in its undergraduate laboratory program.

The corporation took a charitable deduction for the current value of the instruments and found that it was better off by giving them away than it would have been had it traded them in on the new equipment.

HOWARD L. JONES
Colgate University
Hamilton, N. Y.

Con: Trademark Misuse

Sir:

In reviewing the Oct. 31 issue of your magazine, I noted the improper usage of our registered trademarks in connection with the Process Flowsheet (pp. 82-85).

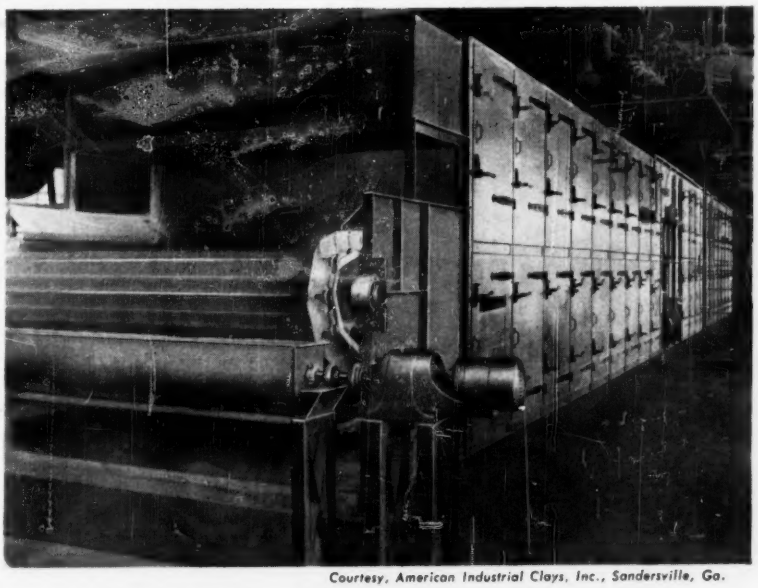
"The Dorr Thickener" is a trademark registered by Dorr-Oliver Inc. in the U. S. Patent Office. As you probably appreciate, if we permit this mark to be used in generic senses rather than indicating origin of goods, there is the chance that we might lose our exclusive rights to this name in time. This fate we are most anxious to avoid,

FOR ALL INDUSTRY WHEREVER THERE'S A DRYING PROCESS

DRYERS *by* SARGENT

Does your product need short or long exposure drying? Is production measured in ounces or tons? Should it be batch or continuous process drying?
Whatever your needs, there's a SARGENT to do the job. SARGENT Dryers are working in widely varied industries — chemicals, rubber, food, tobacco, textiles — wherever there's a drying process. They are pre-dominiant, industry-wide, in profitable operation. Each dryer has these "plus" advantages, standard in every SARGENT machine:

- Exclusive, pre-assembly method means record-breaking speed of installation at your plant.
- Heat source can be gas, oil, steam, electricity.
- Economical — use as little as 1.2 lbs. steam per pound of water removed.
- Drying uniformity; trouble-free operation.
- Rugged construction; takes the gaff of heavy volume production.
- Complete, hold-to-the-line, temperature and humidity controls.
- Dependable, high-level production at unprecedented economy.



Courtesy, American Industrial Clays, Inc., Sandersville, Ga.

SARGENT 2-Stage, Kaolin Dryer With Extruder

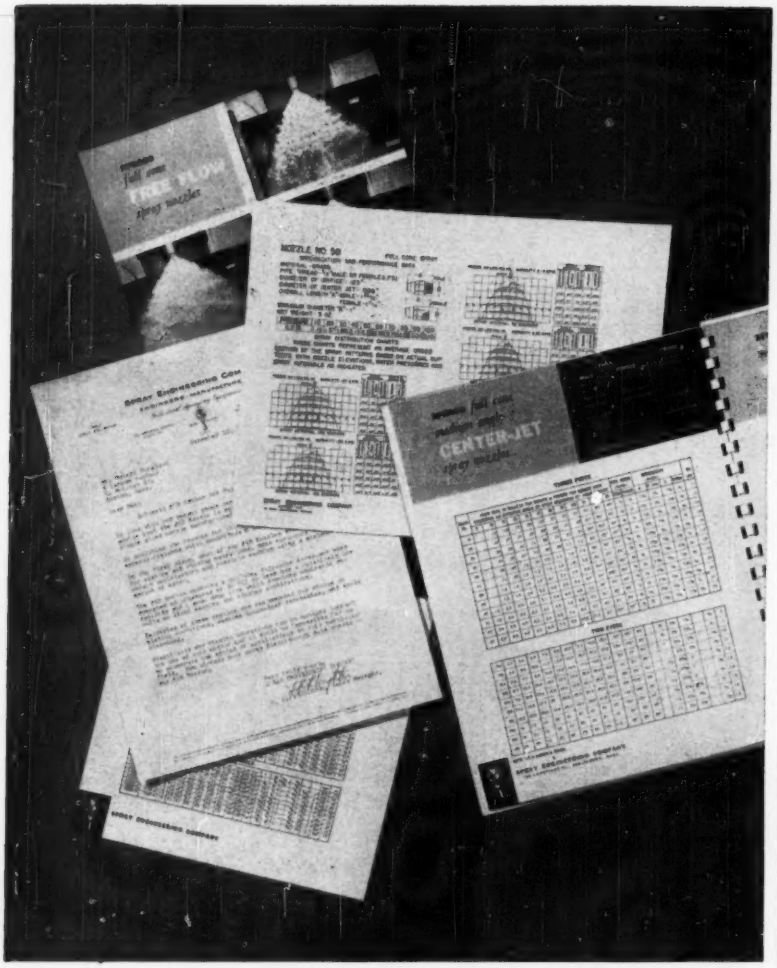
To meet required hourly production in design of this dryer, local conditions suggested the economy of using both gas and oil for the heat source. Combination type burners using both fuels on the same equipment, were therefore incorporated in its design for installation on top of the dryer housing with platforms for inspection and maintenance.

This SARGENT 22-section, 2-stage dryer delivers large tonnage hourly of filler or coating clays. Entering moisture is usually 35% wet basis; and leaves the dryer at 2% or less moisture content, as required. The unique SARGENT double hopper extruder feeds the dryer with a very even porous bed of clay on the dryer conveyor. Simple adjustments easily adapt this machine to various densities of clay.

Another example of SARGENT modern design and advanced engineering in building dryers to meet varying requirements.

C. G. SARGENT'S SONS CORPORATION
Graniteville, SINCE 1852 Massachusetts

PHILADELPHIA • CINCINNATI • CHARLOTTE • ATLANTA • HOUSTON • DETROIT
NEW YORK • CHICAGO • LOS ANGELES • TORONTO



NOW... "SPECS" AT YOUR FINGERTIPS

Here's a surer, easier way to specify spray nozzles

How can you be sure you're specifying the *right* spray nozzle for your particular application?

Spraco's research department has taken the guesswork out of this problem by preparing complete and accurate performance data for each of the hundreds of spray nozzles in the Spraco line. Each nozzle "profile" is complete with data on material, dimensions, flow rate, pressure, angle of spray . . . everything you need to enable you to choose, at a glance, the nozzle that will deliver maximum performance and efficiency in your particular application.

No matter what your spray nozzle problem, Spraco makes this information available to you absolutely free. Why not write and ask about it — today?

SPRAY ENGINEERING COMPANY
115 Cambridge Street, Burlington, Mass.

SPRACO

PRO & CON . . .

as we consider this mark to be a most valuable asset.

PHILIP MINTZ
Dorr-Oliver Inc.
Stamford, Conn.

Pro: Shock-Tube Research

Sir:

We would like to compliment you and Victor Kevorkian on the article titled "Chemical Shock-Tube Research" in your Oct. 3 issue (pp. 107-112). You will recall that the article references the work of this laboratory, specifically of Hertzberg *et al.*

In case any of your readers are interested in more detail on shock tunnel research, we still have copies available of a pertinent article dealing with continuous flows, which we would be happy to send them without charge while the supply lasts.

EDWARD B. CHESTER
Cornell Aeronautical Laboratory
Buffalo, N. Y.

Correction: Storm Sewers

Sir:

Is there something wrong with Table IV in the article, "How to Size Conduits for Storm Sewers" (Oct. 3, pp. 97-98)? It appears that some of the numbers in the first two columns have been transposed.

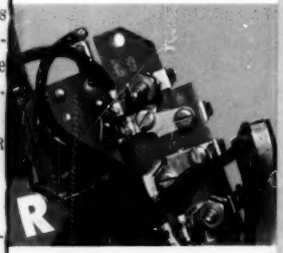
MORTON NEMIROFF
Dole Corp.
Honolulu, Hawaii

▶ *Reader Nemiroff is right. The lower* 16 *numbers in Columns* 1 *and* 2 *have been transposed. This occurred during the editing process while the author's original table was being rearranged. The point where the transposition occurred can easily be spotted.*—ED.

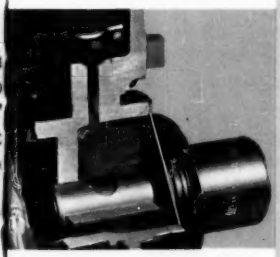
Your comments and opinions are important. Send them to Editor, Chemical Engineering, 330 West 42nd St., New York 36, N. Y. They'll be welcomed.

A NEW Duty Master FHP.

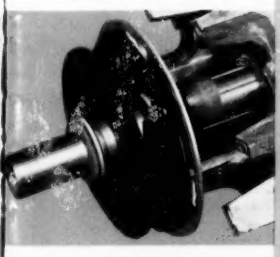
PROTECTED STATOR



TERMINAL BOARD



SLEEVE BEARING



CENTRIFUGAL CUT-OUT

TOUGH...COMPACT...COOL!

A motor that combines new, most-wanted features at no extra cost

Duty Master:

This motor is tough all over . . . deliberately designed for heavy industrial duty. Frame is rolled from steel—end shields cast from an aluminum alloy specifically selected for strength. Ball bearings are double-shielded, with lubricant packed into the bearing for life. Sleeve bearings are steel-backed and babbitt-lined for low friction and long wear. "Permawick" oil retaining material provides maximum lubrication to these bearings. Rotor is pressure-cast from high purity, low-resistance aluminum. Varnish impregnated stator resists moisture . . . and adds strength to windings.

Duty Master:

More power per pound . . . simple installation, 33% lighter than other preceding motor designs. Good design and materials make the difference. Makers of motor-driven products save on shipping and handling costs. Duty Master's light weight and small size make possible lighter, less complex mounting on equipment. Terminal board provides easy power connection in the front end shield. Cover plate quickly removable. Motor rotation easily reversed by interchanging slip-on connections.

Duty Master:

Up to 10% cooler than other comparably rated motors . . . yet gives you maximum protection. High load capacity results from new, effective ventilation of critical heat sources. Laminations, coils and rotor are literally rinsed with cooling air through new end shield design. In totally-enclosed, non-ventilated motors, the fan, cast integrally with rotor, circulates the air within the motor at a rate appropriate to efficient transfer of heat to motor frame and end shield. And load carrying capacity of the totally-enclosed fan-cooled motor is increased by a fan and shroud directing air over the frame and end shield.

Duty Master:

Quiet . . . Smooth . . . Positive. Resilient mounting composed of metal-rimmed, rubber-cushioning rings that encircle the bearing hubs on each end and support the motor. Motor can be mounted in any position. Single phase starter winding circuit automatically opens at 80% of full load speed. Action is quiet and positive.

Available now in 48 and 56 frame sizes, from conveniently located stocks. Duty Master FHP is made in ⅛, ⅙, ¼, ⅓, ½ and ¾ hp. capacitor-start, split-phase and polyphase for 48 and 56 frames; repulsion-start induction-run in 56 frame. Your Reliance Sales Engineer or Distributor has all the facts at his finger tips. Call him or write for Bulletin B-2514. It will be sent to you promptly. B-1675

PRINTED IN U.S.A.

Product of the combined resources of Reliance Electric and Engineering Company and its Master and Reeves Divisions

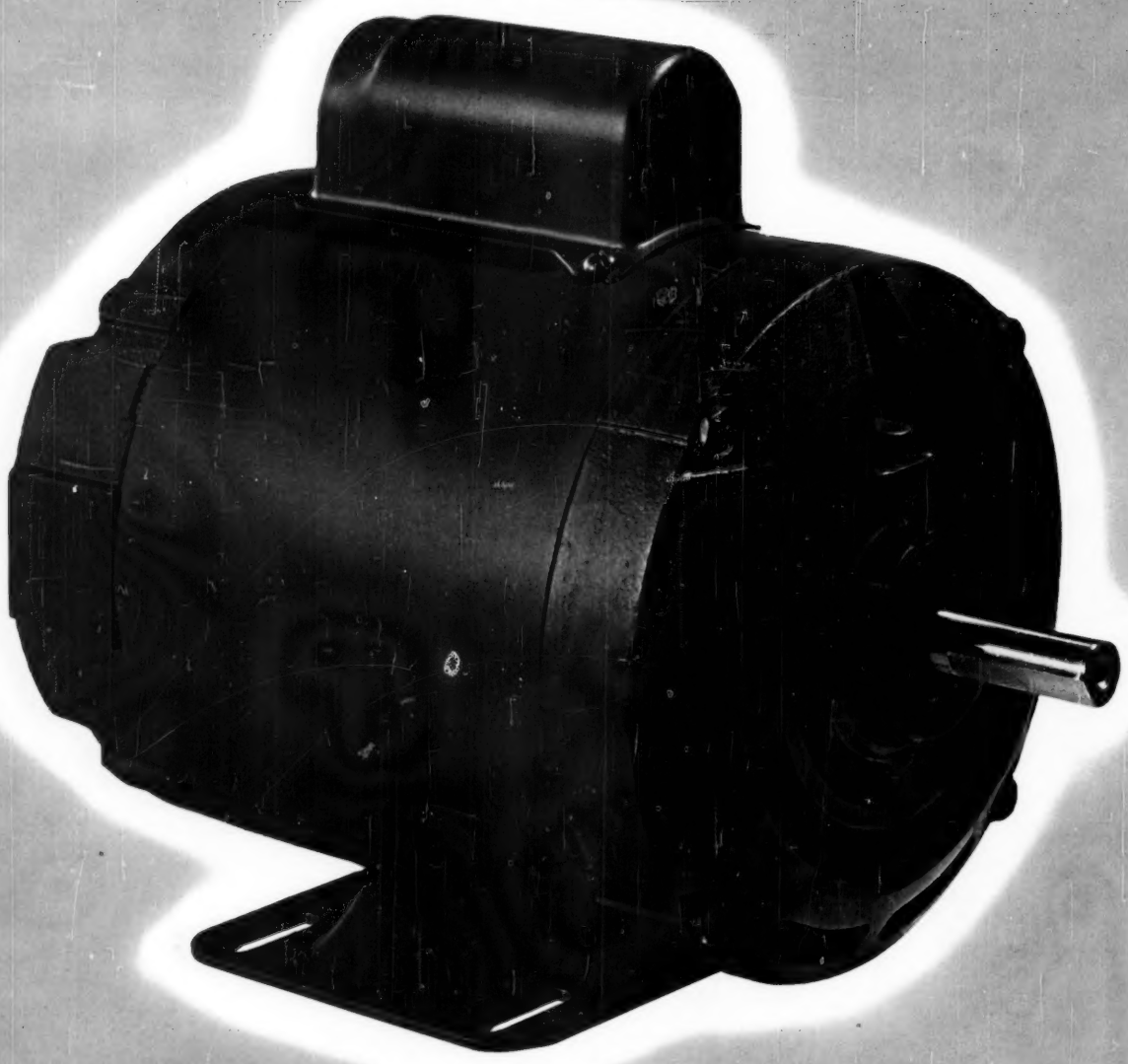
RELIANCE ELECTRIC AND ENGINEERING CO.

CLEVELAND 17, OHIO

Canadian Division: Toronto, Ontario

Sales Offices and Distributors in principal cities

Duty Master A-c. Motors, Master Gearmotors, Reeves Drives, V★S Drives, Super 'T' D-c. Motors, Generators, Controls and Engineered Drive Systems.



A NEW Duty Master FHP.

for heavy-duty industrial use

RELIANCE | **MASTER**

ELECTRIC AND ENGINEERING COMPANY | ELECTRIC COMPANY DIVISION

For more information . . .

- Advertised Products
- New Equipment
- New Chemicals
- Manufacturers' Literature
- Classified Advertisements

Also . . .

- Reprints orders
- Subscriptions

Your Reader Service card is fastest.

USE EITHER CARD

They're easy to fold and tear out . . . try it . . .

PLEASE PRINT ✻

NAME:
TITLE:
COMPANY:
NO. OF EMPLOYEES:
PRODUCT:
ADDRESS:
CITY, STATE:

FIRST CLASS
PERMIT NO. 64
(Sec. 34.9 P.L.&R.)
NEW YORK, N. Y.

BUSINESS REPLY MAIL
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

—POSTAGE WILL BE PAID BY—

Chemical Engineering
READER SERVICE DEPARTMENT
330 West 42nd St.
NEW YORK 36, N. Y.

PLEASE PRINT ✻

NAME:
TITLE:
COMPANY:
NO. OF EMPLOYEES:
PRODUCT:
ADDRESS:
CITY, STATE:

FIRST CLASS
PERMIT NO. 64
(Sec. 34.9 P.L.&R.)
NEW YORK, N. Y.

BUSINESS REPLY MAIL
NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

—POSTAGE WILL BE PAID BY—

Chemical Engineering
READER SERVICE DEPARTMENT
330 West 42nd St.
NEW YORK 36, N. Y.

Help Yourself . . .

The postcards above can now bring you technical help, latest literature, expert guidance. Tear one out and, as you read this issue, circle numbers when you want more information. You'll note that the coding system is simple: all the code numbers are page numbers.

You can also use these post-paid cards to subscribe, or to make your selection from a comprehensive list of editorial reprints.

✻ **Be sure to fill in all of these address blanks before mailing postcard.**

Send CE for ☐ 1 yr. $3, ☐ 3 yr. at $5 (U.S. rate only.) 26

To _____

CIRCLE code numbers for more information. (This Dec. 26 issue card will expire March 26, 1961)

Cov	22-23b	29-30e	47	62C	65	70D	82c	L122	126	R131	156	157D	T160	B168
1	22-23c	32	49	63A	66	73a	82d	R122	126A	132	156A	158	B160	169
2	22-23d	34-35a	51	63B	67	73b	82e	L123	127	133-134	156B	158A	160A	170a
4	24	34-35b	55	63C	68A	73c	109	R123	127A	154	156C	158B	160B	170b
6-7	24A	34-35c	57	63D	68B	73d	111	124	127B	154A	156D	158C	L161	170c
8	26-27	34-35d	58-59a	64A	68C	78	113	124A	127C	155	156E	158D	TR161	170d
9-12	28	37	58-59b	64B	68D	79	115	124B	127D	155A	157	158E	161A	170e
13	29-30a	39	58-59c	64C	69	80	118	124C	128	155B	157A	158F	161B	170f
14-15	29-30b	43	61	64D	70A	81	119	L125	128A	155C	157B	159	161C	170g
18-19	29-30c	45a	62A	64E	70B	82a	120	R125	128B	155D	157C	159A	T168	170h
22-23a	29-30d	45b	62B	64F	70C	82b	121	125A	128C					

Circle KEY NUMBERS for more information about . . .

- ADS
- PRODUCTS page 62
- EQUIPMENT page 68
- SERVICES
- LITERATURE page 154

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W

- CLASSIFIED

REPRINTS: Circle what you want. (See opposite page for description.)

40	42	45	48	49	50	52	54	55	57	58	59	61	62	63	64	66	67	68	70	72	73	
74	75	76	78	79	80	81	82	83	85	86	87	88	89	90	91	92	93	94	95	96	97	
98	99	100	101	102	103	105	107	108	109	110	111	112	113	114	115	117	118	119	120	121	122	
123	124	125	126	127	128	129	130	131	133	135	136	138	139	141	142	143	144	145	146	147	148	
149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169		

FREE REPRINT: Check here ☐ for your file copy of this issue's reprint (p. 99) FC-52

REPRINTS (While they las

Send CE for ☐ 1 yr. $3, ☐ 3 yr. at $5 (U.S. rate only.) 26

To _____

CIRCLE code numbers for more information. (This Dec. 26 issue card will expire March 26, 1961)

Cov	22-23b	29-30e	47	62C	65	70D	82c	L122	126	R131	156	157D	T160	B168
1	22-23c	32	49	63A	66	73a	82d	R122	126A	132	156A	158	B160	169
2	22-23d	34-35a	51	63B	67	73b	82e	L123	127	133-134	156B	158A	160A	170a
4	24	34-35b	55	63C	68A	73c	109	R123	127A	154	156C	158B	160B	170b
6-7	24A	34-35c	57	63D	68B	73d	111	124	127B	154A	156D	158C	L161	170c
8	26-27	34-35d	58-59a	64A	68C	78	113	124A	127C	155	156E	158D	TR161	170d
9-12	28	37	58-59b	64B	68D	79	115	124B	127D	155A	157	158E	161A	170e
13	29-30a	39	58-59c	64C	69	80	118	124C	128	155B	157A	158F	161B	170f
14-15	29-30b	43	61	64D	70A	81	119	L125	128A	155C	157B	159	161C	170g
18-19	29-30c	45a	62A	64E	70B	82a	120	R125	128B	155D	157C	159A	T168	170h
22-23a	29-30d	45b	62B	64F	70C	82b	121	125A	128C					

Circle KEY NUMBERS for more information about . . .

- ADS
- PRODUCTS page 62
- EQUIPMENT page 68
- SERVICES
- LITERATURE page 154

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W

- CLASSIFIED

REPRINTS: Circle what you want. (See opposite page for description.)

40	42	45	48	49	50	52	54	55	57	58	59	61	62	63	64	66	67	68	70	72	73	
74	75	76	78	79	80	81	82	83	85	86	87	88	89	90	91	92	93	94	95	96	97	
98	99	100	101	102	103	105	107	108	109	110	111	112	113	114	115	117	118	119	120	121	122	
123	124	125	126	127	128	129	130	131	133	135	136	138	139	141	142	143	144	145	146	147	148	
149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169		

FREE REPRINT: Check here ☐ for your file copy of this issue's reprint (p. 99) FC-52

REPRINTS (While they las

For Subscriptions: To apply, check here .....
(Pay when billed) Where to send subscriptions .....

Want More Data?

Use this postcard for catalogs . . . for more information on equipment . . . on materials . . . on advertised items . . . for helpful reprints of editorial articles. Be sure to fill out the other side of cards. *Important—For pages showing more than one advertised item, use this guide to numbers on cards above.*

22-23a—Cyanocel
22-23b—Cyamon S & Cyamon S Primer
22-23c—Permal Plus
22-23d—Cyanamer A370
29-30a—Sodium Handling
29-30b—Caustic Soda
29-30c—Chemical Research
29-30d—Anti Static Spray, #1660
29-30e—Instruments, #1661
34-35a—Conical Dryer Blender
34-35b—Series Reactors
34-35c—Glasteel
34-35d—Titan Centrifuge
45a—Alloy-Ni-O-Nel
45b—Corrosion Protection
58-59a—Heat Exchanger
58-59b—NX Desludger Centrifuge
58-59c—Screen Separator
73a—Homogenizers
73b—High Pressure Pumps
73c—Laboratory Homogenizers
73d—Mill
82a—Forged Steel Valves & Fittings
82b—Refrigeration
82c—Special Materials to Combat Corrosion
82d—Process Equipment
82e—Steam Generators
170a—Mixers
170b—Top or Bottom Entering Mixers
170c—Top Entering Propeller Type Mixers
170d—Side Entering Mixers
170e—Portable Mixers
170f—Laboratory & Small Batch Production Type Mixers
170g—Quick Change Rotary Mechanical Seals
170h—Data Sheet For Mixer Re-Requirements

Use this handy coupon to order your personal subscription to Chemical Engineering
No need to send any money now. We'll bill you later.

Reprints Now Available

CE editorial reprints are now easy to get—use Reader Service Card for fast service. For each reprint you want just circle its number on the card. Fill in the blanks on the front, mail. You may send remittance if you wish.

• Materials of Construction

Corrosion—Refresher on cause & cure ($1).....131
High-Temperature Materials—Inorganic, nonmetallic (75¢) 120
High-Temperature Metals—Selection, directory ($1).....129
Lead Installations—Best designs for many uses (50¢).... 79
Nonmetallic Inorganics—For severe conditions (50¢).....125
Materials of Construction—Survey, data, directory ($1)... 58
Plastic Pipe—How and when to use (75¢).....135
Protective Linings—Choice, application, directory ($1).... 88

• Equipment and Design

Air Pollution—CPI plant solutions (50¢).....143
Control Valves—Behavior and selection (75¢).....141
Estimating Engineering Properties
Thermal Conductivity (50¢) 94
Heat Capacities (75¢).109
Latent Heat (75¢)....117
Surface Tension (75¢).126
Viscosity (75¢) 138
Critical Properties (75¢).149
Other Physical Properties (50¢) 151
Flowsheets—Engineering communiques (50¢)..... 99
Flow File—50 design formulas (50¢).....112
Flow Through Packing and Beds
Packed Towers (50¢).....103
Fixed and Moving Beds (50¢).....107
Fluidized Systems (50¢).....108
Heat Exchanger Design—Shortcut methods (75¢)..... 52
Heat Exchanger Calculations—Use these charts ($1).....136
Instruments—"Hardware" section of Report 95 (50¢)..... 96
Mechanical Seals—How to select and use (50¢)..... 83
Piping—Roundup of process pipe, valves, fittings (75¢).... 40
Process Design: Fluid Flow—Size lines, pick pumps ($1)..161
Process Control—Instrumentation report ($1)..... 95
Pump Seals—Chemical plant practice (50¢)..... 92
Water Conservation—Will taps run dry? (50¢).....105
Water Pollution—Solve plant problems (50¢).....122
Your Design Reference File
Parts I-V (75¢).....100
Parts VVI-IX (75¢).....110

• Processes

Biochemicals Processing—The total picture (50¢)..... 93
Bio-oxidation—Treatment of wastes (50¢)..... 68
Chemicals from Petroleum—Available processes ($1).....139
Extractive Metallurgy—By chemical processing (50¢)....111
Ultra-Low Temperatures—Production and uses (50¢).....133
Fermentation—Its chemical technology (50¢)..... 74
High-Temperature Technology—Materials, processes (50¢). 91
Manufactured Gas—To supplement natural gas (50¢)....115
Moving Bed Processes—Theory plus application (75¢).... 64
Nuclear Industry—Role of chemical engineers (50¢)..... 89
Nuclear Wastes—Treatment and disposal (50¢).....150
Odor Control—How to be a good neighbor (50¢)..... 98
Operation & Maintenance—The impact of trends ($1)....121
Photochemical Engineering—Uses, processes, reactors (75¢) 59
Plants & Facilities—Inventory of 1959 (75¢).....158
Processes & Technology—Eighth Inventory 1958 (50¢)...118
Processes & Technology—Ninth Inventory 1959 (50¢)....159

• Costs and Commerce

Buyer-Seller Relations—Vendor's view (50¢).....157
Capital Cost Estimating—Data, sources & methods ($1)...156
CE Cost File—Quick estimating data (50¢).....153
Cost Control Systems—Reduce and control costs (50¢)....102
Cost Estimation—17 articles, 80 pages ($1.25)..... 48
Inflation—How to predict a shrinking dollar (50¢)..... 78
Modernization—Tighten up for profits (75¢).....128
Patent Fundamentals—Timely review (50¢).....114
Petrochemicals—1958 economic review (50¢).....123
Process Energy—Make or buy? (50¢).....142
Professional Registration—For PE-Minded ChE's (50¢)... 85
Rockets and Missiles—Airborne reactor problems (75¢)...119
60's Challenge Chemical Engineers (50¢).....152

• Unit Operations

Absorption With Chemical Reaction—(50¢).....162
Adsorption—Design, methods, materials (50¢).....154
Azeotropic Separation—Close-boiler distillation (50¢).....160
Binary Distillation—Theory, equipment (75¢)..... 54
Compressible Fluids—How to handle ($1)..... 80
Crystallization—For purification (50¢).....124
Drying—Methods, equipment, design, costs (75¢)..... 70
Foams—How to use and control (50¢)..... 86
Ion Exchange—Process, design and applications (75¢).... 55
Liquified Compressed Gases—Handle with care (50¢)....147
Liquid-Gas Contacting—A practical operation study (75¢). 82
Liquid Proportioning—Equipment, methods, uses (50¢)..... 76
Lubrication—For chemical plant engineers (50¢)..... 50
Solids Concentration—Survey of techniques (50¢)..... 67
Solids-Gas Contacting—Commercial practice (50¢) 63
Solids-Liquid Separation—Unit operations description ($1). 62
Solid-Solid Blending—Theory, practice, equipment (75¢).163

• Chemical Engineering Science

Analog & Digital Computers—In engineering use (50¢)...145
Speculative Process Design—Pilot plant bypass (50¢).....146
Pilot Plant—All the aspects of scale up ($1).....127
Statistics—How to use data effectively (75¢)..... 73
CE Refresher
Thermodynamic Principles (50¢)..... 42
Compression & Expansion (50¢)..... 45
Chemical Equilibrium (50¢)..... 49
Homogeneous Kinetics (50¢)..... 57
Catalytic Kinetics (50¢)..... 61
Interpreting Kinetics (50¢)..... 66
Simple Reactor Design (50¢)..... 72
Complex Reactor Design (50¢)..... 75
Catalytic Reactor Design (50¢)..... 81
Reactor Design Problems (50¢)..... 87
Physical Equilibrium I (50¢)..... 90
Physical Equilibrium II (50¢)..... 97
Fluid Flow Equations (50¢).....101
Fundamental Math (75¢).....113
Mass Transfer Operations ($1).....130
Unit Operations Refresher
Fluid Flow (50¢).....144
Sedimentation Theory (50¢).....148
Heat Transfer (50¢).....155
Unsteady State Heat Transfer (50¢).....164

Recent Reprints—to keep your files up-to-date.

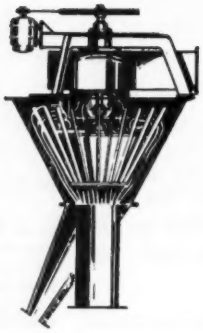
Absorption Methods—Unit operation refresher (50¢)...168
Packaging—Unit containers for chemicals (50¢).....166
Plant & Facilities—Semiannual inventory (50¢).....167
Plant Startups—Systematic preparation (50¢).....165
Process Piping Materials—Selection, directory ($1)....169

change from...

40 MESH

to

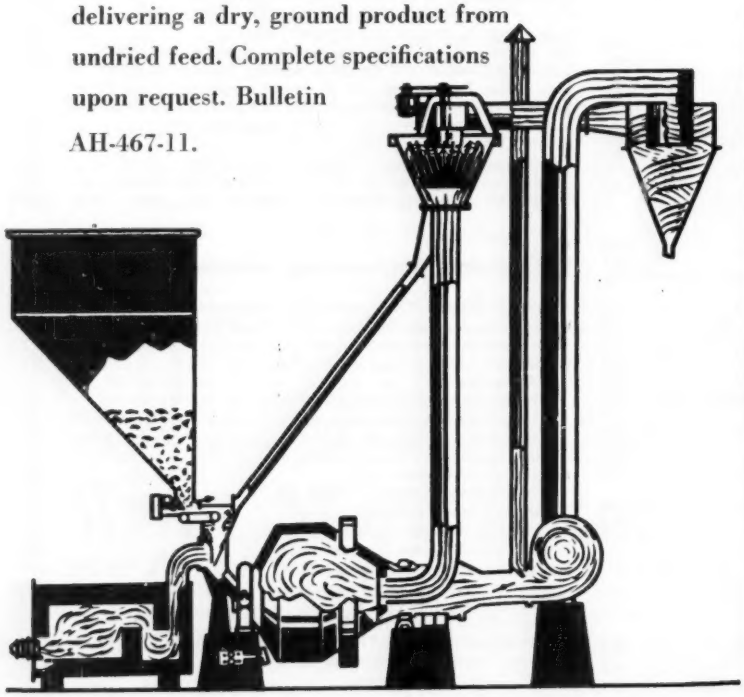
400 MESH



. . . in a few minutes, without interrupting operations. Yet any desired mesh may be maintained continuously. Ease of adjustment and close product control are possible with the . . .

"Gyrotor" Air Classifier

The Hardinge Gyrotor Classifier system, combined with a Hardinge grinding mill is an integrated grinding, classifying and product conveying system. Also available with an air-heating furnace for delivering a dry, ground product from undried feed. Complete specifications upon request. Bulletin AH-467-11.



HARDINGE

COMPANY, INCORPORATED

Main Office and Works • 240 Arch St., York, Pa.

"Hardinge Equipment—Built Better to Last Longer."

NEW YORK
TORONTO
CHICAGO
HIBBING
SALT LAKE CITY
SAN FRANCISCO
HOUSTON
LAKELAND
BIRMINGHAM

Contents of This Issue

Chemicals	154
Construction materials	156
Electrical & mechanical	156
Handling & packaging	157
Heating & cooling	157
Instruments & controls	158
Pipe, fittings, valves	158
Process Equipment	159
Pumps, fans, compressors	160
Services & miscellaneous	161

Chemicals

Anti-Static Spray.....suggested for use during printing & converting of plastics, paper, textiles; during chemical processing; on instruments, etc. No. 1660.
29-30d * U. S. Industrial Chemicals Co.

Catalysts.....The K and DH series catalysts for acetylene removal from gases is covered in detail in Brochure E-1 which is available on request.
67 * Englehard Industries, Inc.

Caustic Soda.....Facts about caustic soda are covered in a new, 36-page booklet now offered. Up-to-date, practical information on properties, applications, etc.
29-30b * U. S. Industrial Chemicals Co.

Chemical Research.....The role of the patent department in chemical research was discussed at the Symposium held by the ACS Div. of Chemical Marketing & Economics.
29-30c * U. S. Industrial Chemicals Co.

Chemicals.....Cyamon S nitro-carbo-nitrate is especially developed for seismograph exploration. Cyamon S Primer is designed to accommodate seismic caps.
22-23b * American Cyanamid Co.

Dispersants.....The Marasperses keep small particles of insoluble solids dispersed. Only a little Marasperse is required to achieve a stabilized dispersion. File E-120.
155 *Marathon Div. of American Can

Ethers.....40-page booklet describes properties and uses of ethers and glycol diethers. Includes information on solubilities and storage plus handling and shipping data.
154A Union Carbide Chemicals Co.

Finish.....Special Permel Plus Finish is formulated specifically to fit the requirements of the fabric. Additional information is available on request.
22-23c * American Cyanamid Co.

* From advertisement, this issue.

Fluorochemicals....Technical data and assistance on Kel-F brand oils, new Fuorel brand elastomer, and Kel-F brand plastic is available on request.
14-15 * Minnesota Mining & Mfg. Co.

Furfural.....for new product or new process development. Additional information plus physical data on Furfural is contained in Bulletin 203-A which is offered.
51 * The Quaker Oats Co.

Glass-Steel.....20-page booklet details steps in manufacture, physical and chemical properties, and end-use of this versatile material of construction.
155A The Pfaudler Co.

Grease.....New Multi-Service Grease Mobilplex EP offers excellent resistance to heat and extra protection against water & rust. Also outstanding oxidation resistance.
6-7 * Mobil Oil Company

Liquid Epoxy Resins.....Literature is available on resin suitable for a wide range of applications, including chemical-resistant coatings, castings, and structural adhesives.
155B Thiokol Chemical Corp.

Modified Cellulose.....Cyanocel chemically modified cellulose is created by treating a purified form of cellulose with highly reactive acrylonitrile. Information.
22-23a * American Cyanamid Co.

Modified Sodium Polyacrylate.....Cyanamer A-370 is dry and granular in composition & dissolves quickly in aqueous solutions. Available from large scale production.
22-23d * American Cyanamid Co.

Oils.....Technical bulletin gives data and use for eleven straight distilled Circo Oils with viscosities ranging from 55 SUS at 100 F. to 140 SUS at 210 F.
155C Sun Oil Co.

Polysulfide Rubber.....Results of a study undertaken to define the resistance of polysulfied rubber to halogenated hydrocarbon fluids are available in bulletin PS-1.
155D Thiokol Chemical Corp.

Want to build up your files and keep them up-to-date? You can get any publication in this comprehensive guide — free — just for the asking.

It's easy — simply circle item's number on the Reader Service Postcard and mail. Replies will come directly from companies offering the literature.

holding down your production rate?

ADD MARASPERSE® DISPERSANTS
to make them thinner and easier to handle.

The Marasperses keep small particles of insoluble solids dispersed, won't let them flocculate or "get together" in water. In slurries this means greater fluidity, because the smaller particles flow past one another more readily than do the larger ones. And in dilute suspensions, it means better suspensibility, because small particles remain suspended longer than do the more sizeable ones.

So, if your products have to be suspended in water for use, avoid customer complaints about sedimentation by using Marasperses in your formulations.

Only a little Marasperse is required to achieve a stabilized dispersion. Usually less than 3% (based on the weight of the solids in an aqueous system) will do the job for you. Pigment dispersions, for example, need only 1 or 2% Marasperse . . . likewise, ceramic clay dispersions and dyestuff pastes. What's more, Marasperses are inexpensive, too!

It's easy to determine whether or not a dispersant can be useful to you. A few quick tests in your laboratory will provide the answer. Write us about your viscosity or suspensibility problems. We'll send you suitable Marasperse samples for evaluation, together with descriptive literature.

MARATHON
A Division of American Can Company
CHEMICAL SALES DEPARTMENT
MENASHA, WISCONSIN

MARATHON • A Division of American Can Co.
CHEMICAL SALES DEPT. • MENASHA, WIS.

Please send Information File No. E-120 ☐, Samples ☐ of MARASPERSE for use in

NAME
TITLE
COMPANY
ADDRESS

Please attach to your company letterhead.

LECTRODRYER® BUDGET AIR DRYER

supplies small quantities of dry air at low cost

If your requirements for very dry air are relatively small—but highly important—you'll find the new Budget Air Dryer tailor-made for your needs. An investment in large equipment is not needed. The Budget Dryer is modestly priced, easily installed and serviced, operates on any 110 volt a.c. line.

NEW BUDGET DRYER IS IDEAL FOR:

- air-operated instrument controls
- electronic equipment
- small cubicles
- pilot plant operations

This entirely new unit supplies up to 20 cubic feet per minute of air, dried to a dewpoint of −60°F or lower. Operation is completely automatic. Likewise, the unit is as foolproof as possible, operating independently of variations in air pressure. Rugged construction and a long operating cycle assure trouble-free use.

Lectrodryer Budget Dryers are standard units, available from stock, shipped ready for installation. For complete information on this new unit and its low cost, write for Bulletin B6A, Pittsburgh Lectrodryer Division, McGraw-Edison Company, 30 32nd St., Pittsburgh 30, Pa.

Lectrodryer McGRAW EDISON

LITERATURE . . .

Silicone Defoamers.....Job-proved as most efficient, economical and versatile foam suppressors available. Free sample and manual on foam control upon request.
140 * Dow Corning Corp.

Sodium Handling....New hydrocarbon desulfurization process, other new uses spur interest in sodium equipment, maintenance, safety. Brochure, "Handling Metallic Sodium."
29-30a * U. S. Industrial Chemicals Co.

Sodium Metabisulfite....Technical bulletin describes the use of material as a low cost preservative for preventing and retarding mold growth in high moisture corn.
156A Monsanto Chemical Co.

Sulfuric Acid.....Technical brochure features enthalpy curves that enable sulfuric acid users to calculate heat developed and final temperatures when acid is diluted.
156B General Chemical Div.

Construction Materials

Alloy.....Bulletin "Engineering Properties of Ni-o-nel" describes composition, physical and chemical properties & includes detailed information on applications.
45a * The International Nickel Co.

Building Panels.....8-page booklet describes applications and advantages of wall panels made of material that exhibits resistance to many severe chemical environments.
156C Resolite Corp.

Corrosion Protection....."Technical Bulletin T-37" offers help in selecting materials to resist severely corrosive conditions. Available on request.
45b * The International Nickel Co.

Packings.....Liquid-Pump packings handle all types of liquids; oil, water, chemicals, brine, etc., under many special operating conditions. Details.
4 * C. Lee Cook Co.

Electrical & Mechanical

Gear-Driven Swivel Joints....are available in 2, 2½, 3 and 4 inch sizes. There is a size and type to meet every requirement. Full catalog and price information.
61 * Continental-Emsco Co.

Generators.....Booklet describes and illustrates new line of generators ranging in horsepower from 20 to 600 and that are guaranteed to operate at 80% of thermal efficiency.
156D Ames Iron Works

Motor.....New Duty Master FHP, is available in 48 & 56 frame sizes. Light weight & small size make possible lighter, less complex mounting. Bul. B-2514.
133-134 * Reliance Electric & Engrg

Variable Speed Drives.....Bulletin shows where and how to use an infinite range, variable speed drive of high accuracy. Principles of operation are also given.
156E Graham Transmissions Inc.

* From advertisement, this issue

Handling & Packaging

Feeders.....Brochure describes improved dry chemical feeders used for a broad range of water and industrial waste process applications. Operating plans included.
157A The Permutit Co.

Packaging Machinery.....4-page folder describes complete line. Specifications, features and illustrations are included in ten types of equipment.
157B Food Machinery & Chemical Corp.

Transportation Equipment.....Every unit is engineered to meet service requirements, including complete piping, metering and transfer equipment. Details.
13 * Pressed Steel Tank Co.

Heating & Cooling

Coils.....Type "R" coils are specially designed for installations where frequent mechanical cleaning of the inside of the tubes is required. Bulletin R-50.
159 * Aerofin Corporation

Cooler.....Roto-Fin's design is simple with minimum number of moving parts for continuous, trouble-free operation. No fans, collectors or elaborate controls are required.
43 * Link-Belt Co.

Coolers, Aero After.....Self-contained systems, independent of any large cooling water supply, they solve the problems of water supply and disposal. Bulletin 130 offered.
L123 * Niagara Blower Co.

Heat Exchangers.....Information on the advantages of price & excellent corrosion-resistance of "Karbate" impervious graphite shell & tube exchangers is offered.
37 * National Carbon Co.

Heat Exchangers.....Plate Heat Exchangers offer a full capacity range of 1600 square feet of exchange area. Capacity is easily increased any time. Just add plates.
58-59a * The De Laval Separator Co.

Heat Exchangers, Pyrex.....Shell & tube, jacketed, cascade & candle-type heat exchangers are made. Design Manual for Pyrex brand modular shell & tube units offered.
28 * Corning Glass Works

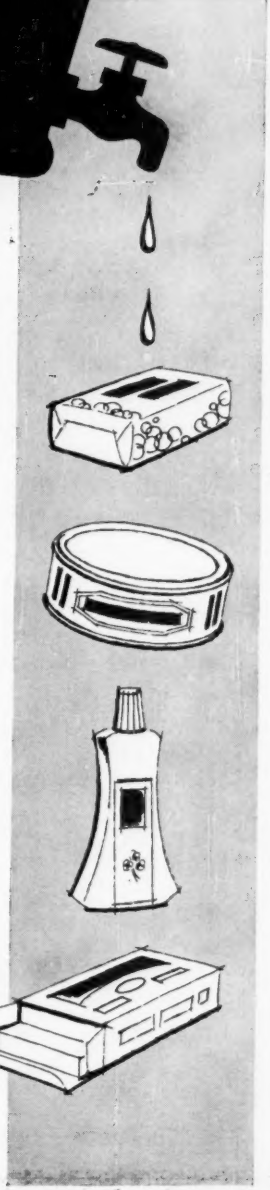
Infra-red Burner.....Data sheet describes burner designed for low-temperature industrial processing applications. Heat emission is concentrated in the 2.0 to 4.0 micron band.
157C Bryant Industrial Products Corp.

Panelcoil.....Latest Technical Data Sheets Nos. 15-60 Series give engineering specifications on Panelcoil. Also prices sent on request. Bulletin 259.
TR161 * Dean Products, Inc.

Storage Water Heaters.....8-page bulletin introduces new line. Complete specifications cover 55 sizes in both vertical and horizontal models plus 114 sizes of U-tube elements.
157D Niagara Weldments Inc.

* From advertisement, this issue

TURN RESIDUE INTO PROFIT



CVC Molecular Vacuum Stills

Ever stop to think that the residue material from your commercial separation process might contain profitable by-products—*extra* profits that can be recovered when you distill in high vacuum with CVC Centrifugal Molecular Stills?

Here's what some industries have recovered:

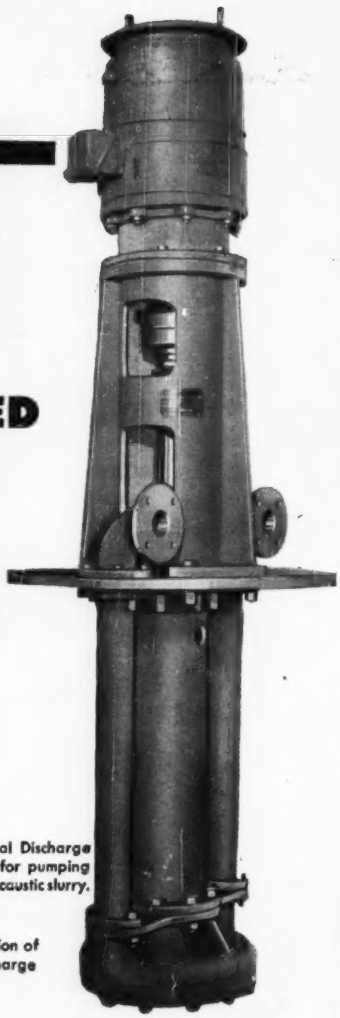
- Rosin (Abietic Acid) from tall oil pitch
- Fatty acids from vegetable oil residues
- Lanolin from wool grease
- Oils and waxes from petroleum residues

And operating costs of CVC high vacuum stills are less than 1/10¢ per pound because of lowered heat input, higher yield.

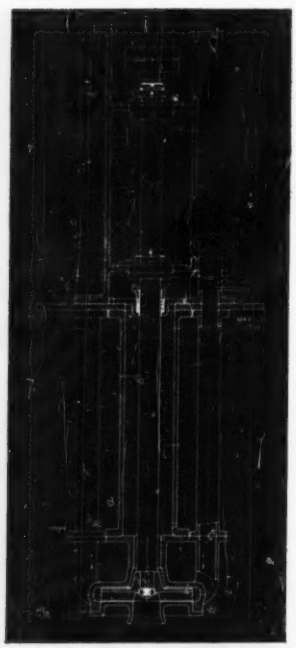
WRITE for Bulletin 3-1 on CVC high vacuum stills. Ask us about the possibility of additional profits from your separation process, and about test runs of your samples.

CVC
Consolidated Vacuum Corporation
ROCHESTER 3, NEW YORK

VERTICAL PUMPS WITH NO SUBMERGED BEARINGS FOR PUMPING ABRASIVE CORROSIVE SLURRIES



2" Dual Discharge Pump for pumping molten caustic slurry.



Cross section of Dual Discharge Pump.

This rugged type of service calls for advanced design: — extra heavy shaft, double-ported casing to equalize the side thrust of the impeller, and tough abrasion-corrosion resistant alloys. The dual discharge pump illustrated here incorporates these features and dispenses with bearings or packing below the cover plate where they would be in contact with the liquid.

Difficult pumping problems, particularly in the process industries, have been our specialty for ninety-one years. Perhaps we can be of help to you. Write us — no obligation.

LAWRENCE PUMPS INC.

Write for Bulletin 251-2 for complete summary of Lawrence vertical pumps.

371 MARKET STREET, LAWRENCE, MASS.

LITERATURE . . .

Instruments & Controls

Instruments.....Infrared spectro-photometers, gas chromatography instruments and accessories are now being leased to users on 3-year basis. No. 1661.
29-30e * U. S. Industrial Chemicals Co.

Recorders.....48-page Catalog C 15-1 highlights new modular design features of the quick changing 2 to 24 point ElectroniK recorder.
158A Minneapolis-Honeywell Regulator Co.

Transmitters.....Full details of the d/p Cell Transmitters as a basis for your control system are contained in Bulletin 13-11A which is available on request.
69 * The Foxboro Co.

Varea-meter.....For truer flow indication, a new high-stability float assures foolproof measurement. There are 29 tube capacities for both scales. Details.
118 * Wallace & Tiernan Inc.

Pipe, Fittings, Valves

Fittings.....W-S forged 150 lb. stainless steel fittings, ideal for pressure services requiring corrosion resistance or roughness. Specifications and distributors.
126 * H. K. Porter Company, Inc.

Fittings & Valves.....Bulletin F-100 covers the deluxe "W"-line of stainless steel sanitary fittings and valves. Includes illustrations & diagrams on the entire line.
158B Waukesha Foundry Sales Corp.

Glass Pipe.....36-page catalog lists all sizes of pipes, as well as fittings, flanges, joints, gaskets, and miscellaneous hardware. Pipe sizes range from quarter-inch to six-inch.
158C Fischer & Porter Co.

Pipe.....Bondstrand is available in sizes from 2" through 8". Bulletin contains complete data, including physical properties, chem. resistance, flow rates, etc.
115 * Amercoat Corp.

Pipe.....Yoloy Continuous Weld and Seamless Pipe offers resistance to atmospheric corrosion, soil corrosion, & chemical corrosion. Details covered in new booklet.
158D Youngstown Sheet & Tube Co.

Tubing.....Weight computation for welded steel tubing are easily obtained from tables included in 16-page brochure that gives dimensions and weight per foot.
158E Jones & Laughlin Steel Corp.

Valves.....The P-K Paul control valves, P-K Paul hose valves and the Ludeman rotoflo valves are illustrated and described in detail in Catalog No. GV 102.
158F General Kinetics Corp.

Valves.....offer many advantages to the processing plant where corrosion, erosion or contamination is a factor. Wide variety of materials available. Details.
78 * De Zurik Corp.

* From advertisement, this issue.

LITERATURE . . .

Valves.....Type G Sleeveline valves are available in ductile iron or stainless steel, screwed or flanged ends, from ½ through 6", with 150 psi rating. Bul. V/12.
113 * The Duriron Co., Inc.

Valves.....Corrosion-Resistant Valves are expressly designed & made to control the flow of acids, alkalies, organic solvents, gases & many other corrosive fluids. Lit.
18-19 * The Wm. Powell Co.

Valves....A complete line of lubricated plug valves, available in sizes from ½" to 36" and pressures to 15,000 lbs. Additional information on request.
26-27 * Rockwell Mfg. Co.

Valves, Gate....Cylinder-operated can use manual or automatic operation, air, oil or water for operating media and are engineered for your application. Info. or quotes.
128 * Darling Valve & Mfg. Co.

Process Equipment

Air Classifier.....Combined with a grinding mill, this system is an integrated grinding, classifying and product conveying system. Bulletin AH-467-11 available.
154 * Hardinge Co., Inc.

Blenders. . ..All welded construction, mild steel or stainless, rounded corners, easily demountable, approved sanitary design. Comes in all sizes. Brochure available.
L125 First Machinery Corp., Falcon Div.

Centrifuge.....Hollow-bowl centrifuge operates on horizontal plane. Continuous separation effected by screw conveyor. Exposure to 2000 G's. Information available.
58-59b * The De Laval Separator Co.

Dryer Air.....operates on any 110 volt a.c. line. Unit supplies up to 20 cubic feet per minute of air, dried to a dewpoint of 60 F. or lower. Bulletin B6A.
156 * Pittsburgh Lectrodryer

Dynamic Washers....The UW-4 washers are ideal for high loading conditions where maximum efficiency is desired. Self-cleaning & fire & explosion proof. Bul. W-7456.
L161 * The Ducon Co., Inc.

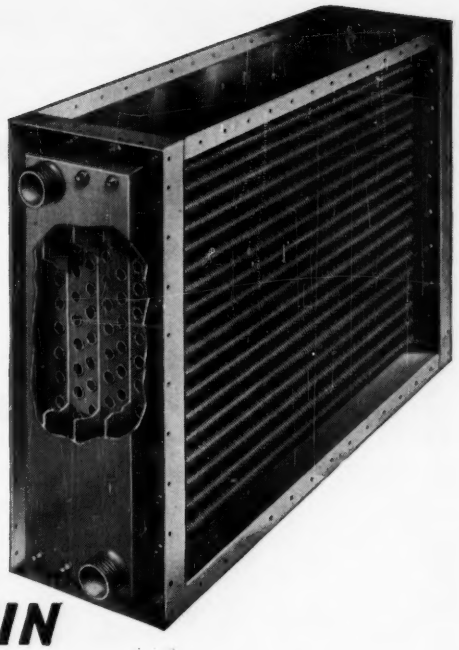
Filters.....that meet exacting filter problems particularly hazardous liquids. Recommendations offered. Manual and automatic operation available.
T160 * R. P. Adams Co., Inc.

Fluid Bed Dryer.....Bulletin 88 covers the design and the principal advantages of the Fluid Bed Dryer. Describes the operation and the typical applications.
159A Combustion Engineering, Inc.

Homogenizers....and Sub-Micron Dispersers reduce ingredients to finer, more uniform particle size. They accent taste & stop color separation. Bulletins offered.
73a *Manton Gaulin Mfg. Co., Inc.

Laboratory Homogenizer.....Minimum sample one pint; capacity 16 GPH; pressure up to 8000 PSI. Additional information is contained in Bulletin LH-55.
73c *Manton Gaulin Mfg. Co., Inc.

* From advertisement, this issue.



AEROFIN TYPE R Removable-Header WATER COILS

- Complete Drainability
- Easily Cleaned
- High Heat Transfer

Completely drainable and easily cleaned, Aerofin Type "R" coils are specially designed for installations where frequent mechanical cleaning of the inside of the tubes is required.

The use of ⅝" O.D. tubes permits the coil to drain completely through the water and drain connections and, in installations where sediment is a problem, the coil can be pitched in either direction. The simple removal of a single gasketed plate at each end of the coil exposes every tube, and makes thorough cleaning possible from either end.

The finned tubes are staggered in the direction of air flow, resulting in maximum heat transfer. Casings are standardized for easy installation.

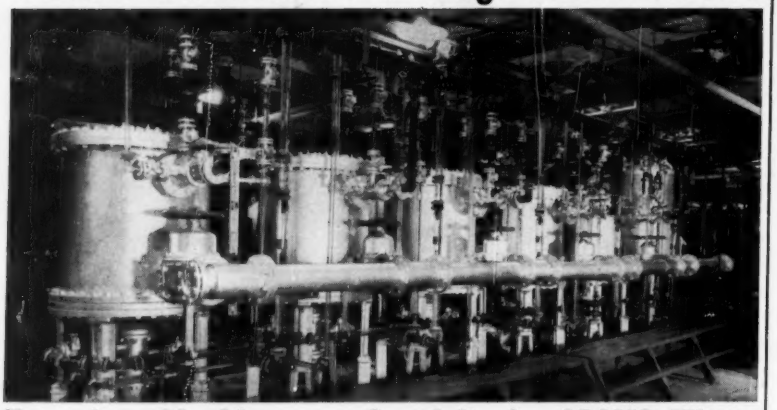
Write for Bulletin No. R-50

AEROFIN CORPORATION

101 Greenway Ave., Syracuse 3, N.Y.

Aerofin is sold only by manufacturers of fan system apparatus. List on request.

ADAMS Filters Meet Exacting Filter Problems



Hazardous Liquids are a Specialty for ADAMS Filters

Hazardous liquids are totally contained in Adams filters. All types of critical liquids — alkaline solutions, mineral and organic acids, and hydrocarbons — are typical of the services where human safety demands no contact between the operator and the product. Adams design permits filtration in a totally enclosed filter which is backwashed without disassembly. Manual labor is minimum as the pressure backwash cleaning requires only the operation of a few valves. Only Adams filters reverse liquid flow at necessary high velocity and pressure to effectively clean the filter medium.

The above Adams installation involves use of inert Poro-Stone elements, rubber-lined filters, and Pyrex pipe to prevent product contamination. Complete removal of colloidal iron compounds from acid solution is dramatically illustrated by dark input and crystal clear output — Pyrex pipe. Three subsequent orders were received from this satisfied customer.

Whatever your filtration problem, an economical Adams plant will meet requirements. Write our sales department today for recommendations. Manual and automatic operation available.

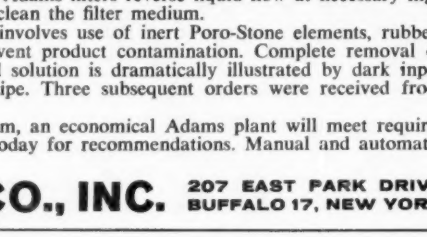
R. P. ADAMS CO., INC. 207 EAST PARK DRIVE BUFFALO 17, NEW YORK

PRATER ROTARY AIRLOCK FEEDERS

for

DUST CONTROL and PNEUMATIC CONVEYING

Write for "How to Select A Rotary Airlock Feeder" Bulletin P58



the recognized LEADER

FOREMOST BUILDERS OF ROTARY AIRLOCKS

PRATER PULVERIZER COMPANY
1517 South 55th Court — Chicago 50, Illinois

LITERATURE . . .

Micronizers.....grind & classify in one operation in a single chamber & provide fires in range from ½ to 44 microns. Eight models are available. Description in Bul. 091.
127 * Sturtevant Mill Co.

Mill.....The two-stage design of the RE Colloid Mill provides continuous micrometer control for producings superior emulsions or dispersions. Bul. C-57.
73d * Manton Gaulin Mfg. Co., Inc.

Mixers.....Bulletin describes design details and gives specification on eleven different sizes of continuous double agitator mixers. Includes photographs.
160A Sprout, Waldron & Co., Inc.

Mixers.....A full line of Flomix, side drive, tank top, portable and tripod mixers are available. Additional information on all types in Bulletin 531A.
111 *Nettco Corp.

Mixers.....A condensed catalog showing all types is offered. You'll find a wealth of information on fluid mixing in helpful bulletins that are offered.
170a * Mixing Equipment Co., Inc.

Molecular Vacuum Stills.....Operating costs of high vacuum stills are less than 1/10¢ per pound because of lowered heat input, higher yield. Bulletin 3-1.
157 * Consolidated Vacuum Corp.

Mulling.....Simpson Mix-Muller is specifically designed to put you in control of mixed properties. The Handbook on Mulling is available on request.
79 * National Engineering Co.

Process Equipment.....Pressure vessels and heat exchangers of any type built. Scientists and engineers available for analyzation and recommendations. Information.
81 * A. O. Smith Corp.

Processing Vessels.....Welded aluminum tanks, pressure vessels and processing equipment for the chemical and processing industries. Booklet "Tank Talks" offered.
B168 * R. D. Cole Mfg. Co.

Rotary Airlock Feeders.....for dust control and pneumatic conveying. Bulletin P58, "How to Select A Rotary Airlock Feeder" is now available.
B160 * Prater Pulverizer Co.

Screen Separator.....Controlled 3-D motion. Simple adjustment of control dials. Quiet, almost vibrational operation. Details available on request.
58-59c * The De Laval Separator Co.

Spray Nozzle.....A comprehensive spray nozzle catalog is available. Contains complete, accurate performance data for each of the hundreds of spray nozzles in the line.
132 * Spray Engineering Co.

Pumps, Fans, Compressors

Compressor.....Brochure describes operating characteristics of 4,000 hp. JM compressor that's advanced cylinder design allows working pressures from vacuum to 15,000 psi.
160B The Cooper-Bessemer Corp.

* From advertisement, this issue.

DUCON
DYNAMIC WASHERS

RECOVER DIFFICULT DUSTS EFFICIENTLY AND ECONOMICALLY

Ducon UW-4 Dynamic Wet Dust Collectors have added a new dimension in dust recovery. They have replaced, with outstanding success, many more costly and less effective dust collectors in the recovery of "difficult" materials, such as fine and abrasive dusts in kilns, rotary driers and other applications.

The UW-4 Washers are also ideal for high loading conditions where maximum efficiency is desired.

Ducon UW-4 Washers offer other unique advantages, including constant air capacity, low water consumption and rugged construction. They are self-cleaning and fire and explosion proof.

Send for Bulletin W-7456.

the name in DUst CONtrol

THE **Ducon** COMPANY INC.
147 EAST SECOND STREET • MINEOLA, L.I., NEW YORK

LITERATURE . . .

Compressors.....built for the rugged duty typical of chemical plants. Heavy casings & conservative rod loadings enables them to easily handle air & gases. Bul. 2561-11.
65 * Joy Mfg. Co.

Fan.....Type XL Fan is built in 16 sizes and four arrangements for volumes to 130,000 CFM, temperatures to 1000 F, pressures to 18". AMCA Certified Rating Seal.
66 * Clarage Fan Company

Pumps.....Bulletin 50 covers both the external gear and bearing type, & the gear-in-head type Rotex pump. Includes approximate dimensions of both & a Selection Chart.
161A Warren Pump Co.

Pumps.....range from 25 to 2500 hp.; pressures to 50,000 psi. Handle corrosive, viscous, abrasive or highly compressible fluids. Complete information available.
24 * Aldrich Pump Co.

Pumps.....Before deciding on type of pumps, see Bulletin V-837, describing the vertical pump, and Bulletin C-355, describing the horizontal pump to avoid misapplication.
R122 * Taber Pump Co.

Pumps.....Provide rugged, reliable, round-the-clock operation under the most severe chemical plant conditions. Complete details and technical data in Catalog 460-C.
120 * American Instrument Co., Inc.

Pumps, acid.....Wide range of corrosive applications. Twenty-four hour maintenance-free operation. Low installation cost, packingless design. Write for complete information.
169 * A. R. Wilfley & Sons Inc.

Pumps, High Pressure.....handle all types of liquids and densities of fluids . . . deliver measured flow in metering applications. Bulletin P-55 offered.
73b * Manton Gaulin Mfg. Co., Inc.

Pumps, Horizontal Split Case.....Bulletin No. 416 describing pumps for water and clear liquid transfer includes dimensional drawings and tables and installation photos.
161B American Well Works

Pumps.....Turbine type, mixed flow & propeller type offer capacities of 50 to 100,000 GPM, heads up to 2,500 ft. Surface or underground discharge. Bulletins.
49 * Layne & Bowler, Inc.

Pumps, Vertical.....with no submerged bearings for pumping abrasive corrosive slurries. Bulletin 251-2 gives complete summary of vertical pumps.
158 * Lawrence Pumps Inc.

Services & Miscellaneous

Sound Barriers.....12-page engineering report explains how to calculate effectiveness of materials as sound barriers. Includes section on "noise criterion" charts.
161C Lead Industries Assoc.

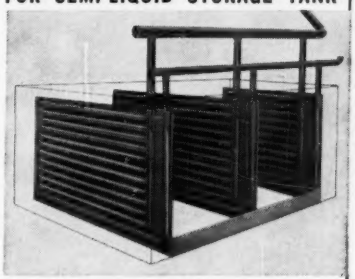
Waste Treatment.....Systems for liquid/solid separation, gravity or pressure separation, by manual, remote or full automatic control or programming are available. Details.
47 * Industrial Filter & Pump Mfg.

* From advertisement, this issue.

Versatile

DEAN PANELCOIL
FOR HEATING—COOLING

FORMS PARTITIONED HEATING UNIT FOR SEMI-LIQUID STORAGE TANK



Dean Panelcoil, because of its greater structural strength, is ideal for building into equipment as part of the shell, bottom, top, or, as shown above, as tank partitions.

In addition, Dean Panelcoil is more economical and efficient than old style pipe coil and conventional jacketing. It generally costs less to install. It takes less room, weighs less and gives fast, even heating or cooling.

Write for Data Sheet 15-60 Series and Price Bulletin 259.

DEAN PRODUCTS, INC.
1039 Dean St., Bklyn. 38, N. Y.
STerling 9-5400
Backed by 25 Years of Panel Coil Manufacturing

PROFESSIONAL SERVICES

ARIES ASSOCIATES, INC.
Consultants to the Chemical Industries
New Products and Processes
New Products Development
Design & Initial Operation of Complete Plants
Process Analysis—Market Research
COMPLETE TECHNICAL & ECONOMIC SERVICES
225 Greenwich Ave. DA. 5-2238 Stamford, Conn.

CARL DEMRICK
Technical Translations
Send for Circular
53 So. Broadway Yonkers, N. Y.

Consult these SPECIALISTS
Let them save your time by bringing their broad experience in their specialty to bear on your problems.

MANUFACTURER'S REPRESENTATIVES

presently serving

CHEMICAL PROCESSING INDUSTRIES

Representation wanted for manufacturer of turbomachinery used primarily for cryogenic and power recovery applications.

STRATOS INDUSTRIAL TURBOMACHINERY DEPARTMENT
BAY SHORE, LONG ISLAND, NEW YORK

A DIVISION OF
FAIRCHILD ENGINE & AIRPLANE CORPORATION

Plastic Panel Technologist Is Sought by Progressive Manufacturer

The basic strengths in sales and research of the BUTLER MANUFACTURING COMPANY have made its Plastics Department a leader in reinforced plastic panels. To take full advantage of our potential, we are increasing the technical strength of our production staff.

We are seeking a man who will be responsible for improving the efficiency of our present panel production—who can relate sales requirements to specifications for new equipment and plant design. In return, we will offer continually increasing responsibility according to your ambitions and performance.

A Bachelor's Degree in Chemistry or Chemical Engineering is preferred. We desire also that you have had laboratory work in reinforced plastics, as well as experience in devising and improving production processes. A real asset in this work will be your proved ability to innovate.

Your answer, which will be kept in complete confidence, should include a personal resume and be sent to Mr. Orval W. Groves, Employment Supervisor, Butler Manufacturing Company, 7400 East 13th Street, Kansas City 26, Missouri.

BUTLER MANUFACTURING COMPANY

ELECTRICAL AND/OR MECHANICAL ENGINEER

Electrical and/or mechanical engineer wanted for expanding development program with modern gravure publication printing company. We want a technical man, well grounded in theory and with the courage of his own convictions. Recent graduate will be considered, but any experience in graphic arts, including paper manufacturing, converting, or allied industries is preferred. Salary open.

Contact:
Mr. D. A. Cutler,
Director of Research & Engineering
TRIANGLE PUBLICATIONS, INC.
440 No. Broad Street, Phila. 1, Penna.

Wanted Electrical, Mechanical or Chemical Engineering graduates to be trained as

SALES ENGINEERS

For our Chicago and Cleveland districts. Prefer men between 25 and 32 years of age who have had industrial process experience. Successful applicants will be given a three-month factory course starting February 1, 1961.

Write Harry E. Beane, Vice President
THE BRISTOL COMPANY
Waterbury 20, Connecticut

METALLURGIST

with production experience in wire drawing, preferably stainless steel. Position: Head of department. Our employees know of this opening.

P-5524, Chemical Engineering
520 N. Michigan Ave., Chicago 11, Ill.

SUPERVISOR

for Wire Drawing Department. Supervisory and metallurgical experience essential. Our employees know of this opening.

P-5525, Chemical Engineering
520 N. Michigan Ave., Chicago 11, Ill.

PLANT STAFF ENGINEER

SALARY $12,000 PER YEAR

B.S. Degree, preferably in Mechanical Engineering; who possesses the ability for design, plant layout, equipment specifications, as would be utilized in a plant engineering department of a chemical plant. Company client assumes all employment expenses.

ESQUIRE PERSONNEL
202 S. State St. Chicago 4, Ill.

MANUFACTURER'S REPRESENTATIVE

Chemical Process Equipment manufacturer of steel and porcelain ball mills, hydraulic mixers, reactors, agitators, conical and ribbon blenders, vibrating screens, sacking sales representative. Several good areas available. Protected territory, commission basis. Well established representative only. Please indicate territory and lines carried. Write to

THE STEVENSON COMPANY
WELLSVILLE, OHIO

ADDRESS BOX NO. REPLIES TO: Box No.
Classified Adv. Div. of this publication.
Send to office nearest you.
NEW YORK 36: P. O. Box 12
CHICAGO 11: 520 N. Michigan Ave.
SAN FRANCISCO 4: 68 Post St.

POSITION VACANT

Wanted: Graduate Chemical Engineers with a minimum of five years experience and Research and Development Chemist with B.S. or M.S. Degree and at least five years experience in research and development activities. Work will be process and product development in phosphate mining and processing operations in large plant with major expansion program now underway. Permanent location in Central Florida. Excellent opportunity for advancement. Salary commensurate with experience. Send detailed resume to Personnel Department, American Cyanamid Company, Brewster, Florida.

POSITION WANTED

Challenge Wanted—ChE., B.S. Notre Dame '58 M.S. Columbia '59, then Army. Want process design position No experience. N.Y.C. Metropolitan Area. PW-5638, Chemical Engineering.

Equipment Searchlight

(Continued on page 163-167)

• IMMEDIATE LIQUIDATION •

From

CRAMET INC. TITANIUM PLANT

CHATTANOOGA, TENNESSEE

MIXERS—2 Baker-Perkins Steam Jacketed Paddle Mixers with 50 H.P. Motors.
DEHUMIDIFIERS—4 Pittsburgh Lectrodryer Dehumidifiers. Type B size, 12-MA, Ser. 5092, (2) Type CH, size X, Ser. 14513-4. Model CH, Ser. 14512.

SPECIAL
Perkins-Elmer In-Line Bichromator Analyzer—New

SCALES—25,000# capacity Toledo Tank Scales.
FANS—36" Stack Fans with Motors.
CRUSHERS—Denver Jaw Crushers (Miscellaneous sizes).
STACKS—9 Refractory Ramed Stacks (Sectional).
MISCELLANEOUS—Several hundred tons Structural Steel, Grating, Pipe, Conduit, and Explosion proof Electrical Equipment. Syntron Feeders with Controls. Rex Bucket Elevator with Drive, etc. etc.

REPRESENTATIVES ON SITE

Complete Details and Quotations Available on Request.

SOUTHERN FOUNDRY SUPPLY, INC.
P.O. Box 566 Chattanooga, Tennessee
AMherst 7-6785

CIRCLE A ON READER SERVICE CARD

DECEMBER SPECIALS

Abbe 5' x 6' J'ktd. Ball Mill, chrome mang. steel
Day 200 gal. sigma arm Jktd. Mixer, 20 hp mtr.
2 Oliver Rotary Vac. Filters, 3' x 2', 63" x 8'
Gruendler "BB" Hammermill, whirlbeater
Ribbon Blenders, Steel & SS, all sizes, New & Used
Pfaudler 1500 gal. glass enclosed top Tank
316SS Fractionating column 2½' x 22'
Blaw Knox Autoclave, 1000 PSI, 347SS, 100 gal.
Gen. American 42" x 120" Twin Drum Dryer

WHAT HAVE YOU FOR SALE OF TRADE?
YOU CAN BANK ON

EQUIPMENT CLEARING HOUSE, INC.
111 33 Street Brooklyn 32, N. Y.
SOuth 8-4451—4452—8782

CIRCLE C ON READER SERVICE CARD

BUY ON TERMS!

DORRCO THICKENER

60' diameter x 35' high 3 tray. Complete with motor and drive. Excellent condition.

PRICED TO SELL

ME MACHINERY AND EQUIPMENT CO.
123 Townsend St. · San Francisco 7, Calif.

CIRCLE D ON READER SERVICE CARD

EXCLUSIVE RIGHTS OFFERED TO MANUFACTURERS OF SPRAY DRYERS

Unique new conception Parallel Spray Dryer, only 32 ft. high, 1000 lbs. water evap/hr. 100% unbroken heads recovered. Instant-soluble products, foods, vegetable chemicals, soaps. By designer original patented Concurrent Dryer. Best ref. All solids contain liquids.

Write Secheurs Atomiseurs Co., 11 Ave, Grande Bretagne, Monte Carlo, Monaco.

CIRCLE W ON READER SERVICE CARD

SEASON'S GREETINGS!

CENTRIFUGES

2—Sharples C-20 and C-27 Super-D-Hydrator, 316 S.S.
1—Bird 18" x 28", Solid Bowl, Continuous, 304 S.S.
1—Bird 32" x 50", Solid Bowl, Continuous, 316 S.S.
1—Bird 36" x 50", Solid Bowl, Continuous, 347 S.S.
3—Sharples PY14, PN14 Super-D-Canters 316 S.S.
1—Tolhurst 26" susp. Rubber Imperforate Basket.
2—Fletcher 48" Suspended 316 S.S. Perforated Basket.
2—Sharples #16, 304 S.S., 3 HP motor.

REACTORS—EVAPS—CONDS—TANKS

1—Glascote 500 gal. glass lined jacketed agitated Reactor.
1—150 gal. 304 S.S. jacketed agitated Reactor.
3—Pfaudler 200 gal. glass lined jacketed Kettles.
1—650 gal. 304 S.S. Reactor with 100 sq. ft. Bayonet Heater.
1—Pfaudler 12" wiped film Evaporator.
1—700 sq. ft. Buflovak 304 S. S. forced circulation Evaporator.
1—550 sq. ft. Buflovak monel single effect Evaporator.
1—7500 gal. 316 S.S. Vert. Storage Tank, 7' x 25', 50 psi.
1—500 gal. S.S. Mixing Tank with nickel coils.
6—7500, 6000 and 2000 gal. Rubber Lined Tanks.
4—1000 gal. 304 S.S. Tanks, 5'6" x 6'.
1—1500 gal. Stainless Pressure Tank, 5' x 10', 90#.
1—2,000 gal. horiz. 304 S.S. tank 5' x 12'.
1—2500 gal. vertical 304 S.S. Tank, 8' x 7'.
1—12,000 gal. horiz. steel Pressure Tank, 7'6" x 36', 200 psi.
6—Stainless Heat Exchangers; 1220, 786, 536, 370, 315, 250 sq. ft.
1—24" dia. x 35', 304 S.S. Bubble Cap Column.

FILTERS

1—#5 Sweetland Filter 304 S.S. 120 sq. ft.
1—Oliver 6' dia. Horizontal Filter, 316 S.S.
1—Oliver 5' x 6' Steel Rotary Vacuum Precoat Filter.
1—U.S. 200 sq. ft. 304 S.S. Auto-Jet Filter.
1—Hercules 400 sq. ft. 304 S.S. Pressure Filter.
1—Oliver 5'3" x 8' Steel Rotary Vacuum, vaportite housing.
1—Feinc 5' x 6' Stainless Steel Rotary Vacuum Filter.
2—#10 Sweetland Filters, 27 leaves, 4" centers, 250 sq. ft.
4—36" x 36" alum. P & E, 65 chambers, 1½" cake, hyd. clos.

DRYERS

1—Buflovak Vacuum Shelf with 20—60" x 80" shelves.
1—Devine Vacuum Shelf with 10—40" x 43" shelves.
2—Buflovak 42" x 120", atmospheric double drum Dryers, complete.
1—Buflovak 32" x 90" Atmos. Twin Drum Dryer.
2—Devine 4' x 9', single drum, atmospheric.
1—Buflovak 3' x 10' Rotary Vacuum Dryer.
1—Baker Perkins 5'6" x 6' Rotary Vacuum Dryer.
2—Buflovak 5' x 30', 3' x 7'6" Rotary Vacuum Dryers 316 S.S.
3—Louisville Rotary Steam Tube 5' x 25', 6' x 35', 6' x 50'.
2—Louisville 8' x 50' Stainless Steel lined Rotary Dryers.
9—Rotary Dryers 34" x 30', 4' x 40', 6' x 50', 6' x 60' 7' x 80', 8' x 87'.
1—Traylor 30" x 18' Stainless Steel Rotary Dryer.
2—Link Belt, 7'5" x 25', 6'4" x 24", S.S. Louvre Dryers.
2—Atmos. Tray Dryers, 16 shelves, 40" x 24".
1—P&S 10' wide Apron Conveyor Dryer 48' long.
2—10' and 4' dia. 304 S.S. Spray Dryers.

MIXERS

1—Farrel-Birmingham "Midget" Banbury Mixer.
2—Day Imperial 150 gal. jktd. double arm.
1—Baker Perkins 100 gal. jacketed double, arm, 30 HP.
1—Baker Perkins 50 gal. jacketed, double-arm.
5—Day "Cincinnatus" double arm, 250 and 100 gal.
2—Steel jacketed Powder Mixers, 225 and 350 cu. ft.
1—Patterson 6' dia. Conical Blender 15 HP.
1—3' dia. Simpson Intensive Mixer.
1—Patterson Kelly 150 cu. ft. Twin Shell Blender.

MISCELLANEOUS

1—Farrel Birmingham 8" x 16" 2 Roll Chrome Plated Mill.
2—Hardinge 5' x 22" steel lined conical Ball Mills.
4—Mikro Pulverizers 4TH, 1 SH, 1 SI and Bantam.
3—Abbe 2½" x 3' porcelain lined Pebble Mill XP motor.
1—Raymond 10" vert. Mill, 10 HP.
1—No. 1 Ball & Jewell Rotary Cutter.
1—#18 Cumberland Rotary Cutter.
3—Swenson Walker Continuous Crystallizers, 24" x 30' sections.
2—#842 Rotex Sifters 60" x 84" double deck.
1—#24 Rotex Sifter, 20" x 64", Quadruple deck.
1—#81 Day Roball Sifter 40" x 120" single deck.
5—Day Roball Sifters, 40" x 120", 40" x 84", Double Deck.
3—Nash H6 Vacuum Pumps.
25—Chlorimet, Durim and Duriron Centrifugal Pumps 1½" to 6".
4—Stokes Rotary Tablet Machines DD2-DDS2-DS3-RB2.

Partial List of Values — Send for Complete Circular

BRILL EQUIPMENT COMPANY

35-61 JABEZ ST., NEWARK 5, N. J. Tel: MArket 3-7420—N. Y. Tel. RE 2-0800
TEXAS OFFICE: 4101 San Jacinto St., Houston 4, Texas—Tel: JAckson 6-1351

CIRCLE E ON READER SERVICE CARD

PEP UP YOUR PROFITS!

GET THE MACHINE YOU NEED NOW!

3—Lawrence type 316 Stain. Vert. 3" submerged Pumps. 250 GPM A100'

2—Sutorbilt 14"x10" Posit. Blowers. 125 HP 900 RPM. 2400 CFM @10#

2—Elliot type O Blowers. 6000 CFM @5.5# pressure. 200 HP

2—Sharples PN-15-Super-D-Cantors 316 stainless contact. 10 HP Mtr

5—New Jeffrey 6" and 6½" Stain. Tub. Vibr. Conveyors. 12 & 15' long

2—Raymond #1 auto Pulverizers. Comp/5/6" Whizzer Separator

1—New Blaw-Knox Comp. Rotocel Extraction unit. 350 TPD

1—Bird 40"x60" S S horiz. Cont. Centrifuge. 50 HP Motor

ME MACHINERY AND EQUIPMENT COMPANY
123 Townsend St. · San Francisco 7, California

CIRCLE F ON READER SERVICE CARD

LOEB OFFERINGS

Autoclave: 50 gal. Struthers Wells, st. st.
Centrifugal: AT&M 60" st. st. perf.
Dewaterers: Davenport 3A, bronze hd. 3 hp.
Disintegrator: Rietz RD-12, 15 hp.
Dryers: Devine 2 x 4' vac. drum. st. steel.
Dryers: Bowen lab. spray, st. steel.
Dryer: American atmospheric, 24 x 48".
Column: 24" x 22', 316 stain. steel.
Evaporator: Buflovak st. st., 94 sq. ft.
Filter: Sweetland #5 st. st. lined.
Filter: Oliver precoat 12 x 2" st. steel.
Filter: Eimco st. st., drum 16" x 12".
Filter Press: Shriver 24" St. steel.
Homogenizers-Disperser: Tri-Homo #10, #4.
Homogenizers: 25, 50, 125, 200, 1200 GPH.
Kettles: st. steel with and without ag.
Dopp 150 gal. dbl. act. agitator.
Mill: Fitz model D-6 st. steel, 7½ hp.
Mill: J. H. Day 16 x 40" 3-roll high speed.
Centrifugal: Tolhurst 48" st. steel.
Mixers: Dbl. and sgl. arms sigma blade.
Dry Powder, various sizes.
Pumps: Rotary, gear, centrif., vacuum.
Percolator: Pfaudler 300 gal. st. steel.
Dryer: Proctor & Schwartz 6-tray St. steel.
Tablet Press: Stokes DD2, 23 station.
Vacuum Pans, 42" and 72" stain. steel.

LOEB EQUIPMENT SUPPLY CO.

CIRLCE G ON READER SERVICE CARD

Season's Greetings from The Entire FMC Staff

SPECIAL OFFERING DIRECT FROM LOCATION
CONTINUOUS FINE GRINDING EQUIPMENT
Being Removed as Operations Terminate

2—Allis Chalmers 7′ x 22′ (2 Compartment) Compeb Ball Mills with Meehanite Liners; each driven by a magnetic-coupled 400 HP Motor

1—Allis Chalmers 9½ x 810 Preliminator or Continuous Ball Mill; Meehanite Liners, driven by a magnetic-coupled 400 HP Motor

3—Allis Chalmers 7′ x 22′ Continuous Ball Tube Mills, with Meehanite Liners, each driven by a magnetic coupled 400 HP Motor now operating in closed circuit with

3—Raymond 14 Ft. Double Whizzer Mechanical Air Separators, each driven by 75 HP Motor. May be purchased separately.

MILLS—PULVERIZERS

2 Stainless Micronizers 30".
Ball Mills and Pebble Mills by Abbe, Patterson, International Some Jacketed; up to 8′x8′.
Mikro Pulverizers up to No. 4's.
Fitzpatrick Comminutators; Models D, K and C; motorized.
American Ring Roll Crusher; 50 HP.
Mikro S/S Atomizers; Nos. 6 and 5.
Raymond Imp Mills; many sizes.
Williams Hammer Mills to 60 HP.

REACTORS — PRESSURE VESSELS

2 Stainless 400 gal. Reactors Jktd. Agtd. by Patterson and Struthers Wells.
Dorr-Oliver 500 gal. 5′x5′ Stainless Thickener or Reactor.
Stainless Reactor, 2000 gal. Fully Jktd. Agitated.
Nickel Clad Reactor, 7′x11′6".
2 MONEL Reactors; 2800 gal. 6′8"x13"; ASME Jktd. & Intern.
3 Stainless Vert. Pressure Tanks; 42"x10′; closed dished heads.
6 Heavy Duty Stainless Tanks; 850 gal. with S/S Agitators.
Pfaudler GL Lined Reactors; all sizes from 50 to 1000 gal.
Mojonnier Stainless Vac. Pans; 3′x10′ and 6′x12′; others.

CENTRIFUGES

Stainless Centrifugals from 30" to 60"; A.T.&M. Tolhurst, Fletcher, etc.
2 Sharples Stainless Steel Model PN14 Super-D-Canters.
4311 S 1 Sharples C 27 Super-D-Hydrator in Type 316 Stainless with 40 HP Motor.
5147 S 13-14 Two Bird Continuous Screen Type Horizontal Centrifuges; Monel & S.S.; 24" x 24".
2 Bird Rubber Covered, 48" with Plows; Fume Tight; 40 HP.

EVAPORATORS — DRYERS

Buflovak S/Steel Thermo-Recompression Evaporator; Sanitary with all accessories.
Buflovak S/Steel Dbl. Effect Evaporator Model 8½-60 D.
Pittsburg Lectro Dryers, Bac 25 and BWC 3400.
Devine Vac. Chamber Dryers, Double Door Model No. 36.
Stainless Lab. Drum Dryer, 8"x11½" complete.
Bowen S/S Lab. Spray Dryer.
Louisville S/S Rotary Dryer, 30" x 28'; Indirect fired.
Louisville MONEL Rotary Steam Tube; 54" x 35".

MIXERS ALL TYPES

Baker-Perkins Jktd. 5 gal. UNE-7, Dbl. Arm Mixer with pressure cover; 30 HP.
Readco Jktd. 15 gal. Dbl. Arm Sigma Blade Mixer.
Patterson Conaform S/S Vac. Blender, 13.7 cu. ft. Jacketed.
Stainless Steel 150 gal. Jktd. Dbl. Arm Mixer with Vac. Cover; Hydr. Tilt;
Other Baker Perkins Jktd. Mixers, 200 and 300 gal.
J. H. Day Cincinnatus Dbl. Arm Mixer; 300 gal. STAINLESS Jacketed.
NOW IN STOCK for IMMEDIATE DELIVERY. ALL SIZES FALCON Ribbon Blenders in Steel or Stainless.

FILTERS — FILTER PRESSES

4 Pressure Filters 30"x56" Type 316 Stainless; 100 sq. ft.
Sparkler S/S Filter Model 14 S 4.
Sparkler Steel Filter Model 33 S 17.

OLIVER PRECOAT FILTERS

3"x2" Monel. 5′3"x8′ Stainless.
(2) 5′3"x3" Steel or Rubber.
Feinc S/S Rot. Vac. Filter 3′x1′.
Oliver Cont. Rot. Vacuum Filter.
Panel Type; 8′x8′ and 8′x10′.
S/S Nutsche Type Filter; 6′x2′.
Bowser Filter with Pump; 2000 GPH.
Shriver and Sperry Plate & Frame Filter Presses up to 42" in Cast Iron, Stainless, Ni-Resist, Rubber Covered or Wood; all Types.

SPOTLIGHT SPECIALS

Komarek Greaves Briquetting Presses; 75 HP
Stokes Double Chamber Impregnators
Stokes Model #280 (80 Ton) Press; 7½ HP
Stokes # 252 Aut. Closure Press; 150 HP
Flash Drying System in Type 316 Stainless
Rotex and Ro-Ball Sifter Screens, all sizes
Hardinge Conical Ball Mill; 8" x 36" Complete
F-B Unused Late Type 2 Roll Mills; 14" x 30"

FIRST MACHINERY CORP.

209-289 TENTH STREET, BROOKLYN 15, N. Y.

FMC Pays MORE For Your Surplus

PARKING ON THE PREMISES
Phone: STerling 8-4672
Cable Address: "EFFEMCY"

CIRCLE H ON READER SERVICE CARD

LIQUIDATION
ALCOHOL PLANT
OMAHA, NEBRASKA

MAJOR ITEMS

5—Buflovak 42" x 120" dbl. drum dryers, ASME 160#
2—Bonnet 7′ x 60′ rotary dryers,
1—Bonnet 6′ x 52′ rotary dryer,
9—Davenport #1A #2A dewatering presses
2—French Oil screw extrac. presses,
2—Sweetland #12 pressure filters,
3—Lawrence 4" x 3" stainless centrif. pumps, 275 GPM @ 40′ head
6—Shriver 48" Cast Iron P. & F. filter presses, (50) chambers, hydraulic closure, closed deliv.
2—19,900 sq. ft. quadruple effect calandria type evaporators, copper tubes, cast iron bodies, with preheater & finishing pan
6—Ansonia 691 sq. ft. dbl. pipe coolers, copper tubes
3—American 654 sq. ft. spiral steel heat exchangers
1—1500 sq. ft. horiz. exchanger, (480)—¾" OD copper tubes, copper T. S. & shell, steel heads
18—Tubular heat exchangers, copper tubes: 1500, 1350, 1130, 637, 380, 290, 184, 176, 156 sq. ft.
1—ACME 96" dia. x 44′ high copper beer still column, (20) perforated & (4) bubble cap trays
5—Leader Iron 96" dia. steel rectifying columns, 44′ & 51′ high, bubble cap trays
2—9500 gal. horiz. cookers, 9′ dia. x 20′ long, ½" shell & dished heads, agits.
4—Wallace & Tiernan auto. bulk handling scales
10—Forster hammermills, #8 & #6, 100 & 75 HP.
1—Stedman 36" dia. 3-row cage mill disintegrator
1—Prater "Blue-Streak" pulverizer,
1—Fuller 12 x 20 pos. press. blower
2—Allis-Chalmers Inter-plane grinders, 100 HP
1—"Jay Bee" #4 hammermill,
9—Davenport 5′ x 25′ inclined "slop" screens
2—Warren 12" x 12" cent. pumps
250—Steel centrifugal pumps, 1" to 12", 1 HP to 150 HP
2—Aldrich vert. triplex plunger piston-type pumps, steam drive
100—Steel & stainless steel screw conveyors, up to 161′ long
5000 HP—TEFC motors, 3/60/220-440/, to 150 HP
20—Steam turbines, to 150 HP
200—Steel tanks & bins, all sizes
12—300 amp. portable welders, elec. & gasoline

SEND FOR CIRCULAR #960-A

PERRY EQUIPMENT CORP.
1413-21 N. Sixth St.
Philadelphia 22, Pa.
Phone POplar 3-3505

CIRCLE J ON READER SERVICE CARD

SEASON'S GREETINGS

FROM ALL OF US AT PERRY!

RECENT STOCK PURCHASES!

1—60" dia. x 35 plate T316 SS bubble-cap column
1—Buflovak 6" x 8" vacuum dbl. drum dryer
1—American 42" x 120" dbl. drum dryer, ASME
5—1350 gal. T347 SS jacketed kettles, agit.
2—100 gal. T304 SS jkt. reactors, ASME, UNUSED
1—1800 gal. T316 SS jacketed reactors, VACUUM
2—Mikro #3TH pulverizers, stirrup hammers
1—4300 gal. T304 SS horiz. tank, ASME 50# WP
3—Komarek-Greaves 160,000 psi briquette presses
1—Patterson 6' x 10' jkt. pebble mill, porcelain
1—Raymond 50", 5-roller hi-side mill, dbl. whizzer
1—J. H. Day #8 Cinc., 150 gal. dbl. sigma mixer

KETTLES-REACTORS

1—1900 GAL. T316 SS JKT. REACTOR, 5 HP AGIT., VACUUM
5—1350 GAL. T347 SS JKT. KETTLES, ANCHOR AGIT.
1—1000 gal. Dopp cast iron kettle, jkt., 25 HP agit.
1—750 gal. T304 SS jkt. fermenter, ASME, 10 HP agit.
1—750 gal. Pfaudler glass-lined jkt. reactor
1—600 gal. Pfaudler glass-lined jkt. reactor
1—600 gal. T304 SS jkt. crystallizing kettle, agit.
2—500 gal. Pfaudler glass-lined jkt. reactors, agit.
6—465 gal. T304L SS jkt. reactors, 175# WP
2—125 gal. T316 SS jkt. fermenters
2—100 GAL. T304 SS JKT. REACTORS, ASME, VAC. UNUSED

FILTERS-CENTRIFUGALS

2—Oliver 5'-3"x3' rot. vac. filters, T316 SS, precoat
1—Oliver 5'-3"x8' rot. vac. filter, precoat, UNUSED
1—Oliver 5'-3"x8' rot. vac. filter, monel screens
1—Niagara #510-28, 510 sq. ft. T316 SS leaf filter
2—Sweetland #12 steel filters
6—Shriver 48" cast-iron P. & F. filter presses, (50) chambers
22—Sharples #AS-16V super centrifugals, inconel, vapor-tite, sludge, disch. frame
2—Sharples #C-20 Super-D-Hydrators, T316 SS
2—Sharples #C-27 Super-D-Hydrators, T316 SS
1—Bird 18"x28" T304 SS contin. centrifugal
1—Bird 24" x 38", T316 SS contin. centrifugal
3—Bird 24"x24" monel centrifugals, type CH
1—Bird 32"x50", T316 SS contin. centrifugal
1—Tolhurst 48" susp. basket centrif., T304 SS
6—AT&M 40" susp. basket centrif., T304 SS
1—Bird 40" susp. basket centrif., steel
1—Fletcher 40" susp. basket centrif., steel
2—AT&M 32" susp. basket centrif., T304 SS
1—Tolhurst 26" susp. basket centrif., steel
1—AT&M 12" susp. basket centrif., T304 SS

MIXERS-MILLS

55—Baker-Perkins #17, 200 gal. sigma, jkt.
2—Baker-Perkins #16, 150 gal. sigma, jkt.
1—J. H. Day #8 cinc., 150 gal. sigma
1—Baker-Perkins #15-UUMM, 100 gal., dispersion blades, jacketed, 100 HP drive, compression cover.
3—Baker-Perkins #15, 100 gal. sigma, jkt.
2—J. H. Day #5 cinc., 75 gal. sigma.
1—J. H. Day #2 cinc., 20 gal. sigma, jkt.
1—Raymond 66", 6-roller mill, 200 HP
2—Raymond 50", 5 roller hi-side mills, dbl. whizzer or dbl. cone, rebuilt
1—Kennedy-Van Saun 7' x 9' contin. ball mill
2—Hardinge 7' x 36" conical pebble mills
12—Abbe Eng. #1B, 6' x 8' batch pebble mills
1—Patterson 6' x 10' pebble mill, porcelain jkt.
2—Mikro #3TH pulverizers, stirrup hammers
1—B. & W. #E-32 pulver., air-swept, 75 HP

HEAT EXCHANGERS-CONDENSERS

1—1960 sq. ft. T316 SS exchanger, ASME 75 #WP
1—1450 sq. ft. T316 SS condenser, 1" OD tubes
1—880 sq. ft. T316 SS condenser, 1" OD tubes
3—800 sq. ft. T316 SS condensers, 5/8" OD tubes
1—730 sq. ft. T316 SS condenser, 1" OD tubes
5—T316 SS condensers: 510, 427, 425, 410, 400 sq. ft.
25—T316 SS condensers: 290, 277, 264, 250, 200, 185, 165, 150, 145, 105, 83, 73, 54, 52, 30 sq. ft.

STAINLESS STEEL TANKS

1—5700 gal. horiz., T304 SS, 6'-4" x 24', UNUSED
2—4500 gal. vert., T304 SS, 8' x 12', UNUSED
1—4300 GAL. HORIZ., T304 SS, 6' x 20', DISHED HEADS
1—3700 gal. vert., T304 SS, 6' x 17', VACUUM
1—3400 gal. horiz., T304 SS, 6' x 16', dished heads
1—3300 gal. vert., T304 SS, 6' x 14', dished heads
1—3000 gal. vert. T304 SS, 6'x15', coils, VAC.
3—2750 GAL. VERT., T316 SS, 7'x8', DISHED HEADS
1—2500 gal. vert., T316 SS, 7'x7', dished heads agit.
2—2300 gal. vert., T316 SS, 7'x8', coils, agit
4—2250 GAL. VERT., T316 SS, 7'x6'-3", DISHED HEADS
1—2100 gal. vert., T316 SS, 6'x9'-10", cone bottom
1—1750 gal. vert., T304 SS, 5'x12', coils, VAC.
12—1750 gal. vert., T304 SS hoppers, 235 cu. ft.
1—1250 gal. vert., T304 SS, 5'x12', coils, VAC.
2—1000 GAL. VERT., T304 SS, 5'5"x6'x2", UNUSED
6—685 gal. vert., T316 SS, 3'x13', coils
1—600 gal. vert., T304 SS, 5'x4', dished heads

PERRY EQUIPMENT CORPORATION

1413-21 N. SIXTH ST. PHILADELPHIA 22, PA.

Phone POplar 3-3505

CIRCLE K ON READER SERVICE CARD

LIQUIDATING

10 MILLION DOLLAR **CHEMICAL PLANT** NORTH JERSEY AREA

TYPE 316 STAINLESS STEEL EQUIPMENT

1—2600 gals. type 316 SS vertical vacuum receiver
2—Rubber lined horiz. storage tanks, 5500 gals., working pressure 45#
6—Rubber lined vertical storage tanks, 4500 gals., working pressure 45#
2—Rubber lined vertical storage tanks, 2500 gals., working pressure 45#
2—Buflovak type 316 SS jacketed rotary vacuum dryers, 5' x 30', complete with 25 HP explosion proof motors and drives
3—Type 316 SS ter-meer continuous type centrifuges, 4' dia. bowls, complete with motors
1—Readco stainless steel horiz. blenders, 450 cu. ft. working capacity, complete with 75 HP motors
3—Mikro Model 3TH stainless steel pulverizers, complete with 40 HP explosion proof motors
2—Nash SH-6 SS vacuum pumps, complete with 20 HP motors
2—Aldrich Groff type 316 SS hydraulic triplex pumps, size 2¾ x 4 at 500 psi
2—Powell type 316 SS, 10" hyd. oper. flanged and gate valves
3—Tyler type 38 tandem SS hummer screens, size 42" x 9'8"
3—Williams type 316 SS hammermills with 10 HP motors
2—200 gals. type 316 SS jacketed kettles
4—Patterson-Kelley SS heat exchangers, 235 sq. ft. and 300 sq. ft.
500 tons of type 316 SS pipe, fittings and valves, from 2" to 6"
500 tons of structural steel

R. GELB & SONS, Inc.

U. S. HIGHWAY 22, UNION, N. J. MUrdock 6-4900

CIRCLE L ON READER SERVICE CARD

---

4 CHEMICAL PLANT LIQUIDATIONS

NIAGARA FALLS, N. Y.
EVERETT, MASS.
BALTIMORE, MD.
JERSEY CITY, N. J.

Catalogs Available. Write for Your Copy

HEAT & POWER CO. INC.

60 E. 42nd St., N. Y. 17 MU 7-5280

CIRCLE R ON READER SERVICE CARD

Buffalo 32"x90" Double Drum Dryer.
Day Hy—R Speed Mill 20 HP Expl. Pr.
Centrifugals: 12", 30", 40" & 48".
Centrifuges: Sharples #5 & #6 Stainless.
Dryers: Hersey 5'x26' Rotary, 316 Stainless
Buffalo Vac. Drum Dryer 24"x20".
Despatch Ovens Elec. Heated.
3—Devine & Stokes Vac. Shelf Dryers
Filters: #2 Sweetland 12 Stainless Leaves.
Filter Presses: 6" to 36" Iron & Wood.
Kettles Tanks: S.S. Jack 20 to 4000 gal.
New Stainless 4000 gal. vert Tank
Dopp 350 gal. cast iron Jack. Vacuum.
Devine Impreg. Units 30" & 36" dia.
Mills: Raymond #00, 30 HP. & #0000.
Mikro Pulverizers #4, 2, 1, & Bantam.
Hammer Mills & Pulverizers 3 to 50 HP.
Taylor-Stiles 7½ HP. Cutter.
Rotary Cutters 1½ to 5 HP. & up.
Spr. Waldron Stainless spike crusher.
Pebble, Jar & Ball Mills, Lab. to 6' x 8'.
3 Roll, 9" x 32", 12" x 30", 16" x 40".
Lehman 4 Roll W.C. 12' x 36" Steel.
Colloid Mills 1½ H.P. & up.
Mixers: Baker Perkins jack. 100 gals.
B.P. 15 HP. Masticator Mixer.
Day Imperial 75 & 150 gals.
Change Can Mixers 8, 15, 40, 150 gal.
Sprout-Wald. 10,000# horiz. Spiral Mixer
Day Jumbo 700 gal. horiz. mixer.
Spiral Mixers, 3000, 1000# etc.
Lancaster 6' dia. 25 HP, & #1, 3 HP.
Pumps: Stokes etc. Vac. 10 to 500 CFM.
Gould 75 HP. Centrifugal 250 PSI.
Sifters: Day, Robinson, Rotex type.
Tablet Machines: Stokes R, Colton 4½ T, single punch. Also Rotarys.
Hydr. Presses, Plastic & Rubber Machy.

Partial Listings. Write For Bulletins

STEIN EQUIPT. CO.

107-8th St., Brooklyn 15, N. Y. Sterling 8-1944

CIRCLE M ON READER SERVICE CARD

Baker Perkins 150 gal 40 HP, 100 gal 50 HP. Both S.S. 2 arm jacketed vacuum hdr. tilt.
Aluminum Condenser 350 sq ft.
Aluminum Evaporator Calandria type, never used. 1300 sq feet tube area.
Continuous Stripping column 2 x 13 Steel.
Hydraulic Pumps & Meters.
Dryers Vacuum Shelf.

MACHINECRAFT CORPORATION

800 Wilson Ave. (East of Doremus)
Newark 5, N. J. MI 2-7634

CIRCLE O ON READER SERVICE CARD

FILTER PRESSES—6" Iead P&F w/pump, 18x18 (26 chamber), 30x30 (11 chamber)

MILLS—Hardinge Conical, 3'x8", 3'x24", 5'x22", 8'x36", 8'x48", 6'x12' rod w/200 HP

VACUUM PUMPS—115 CFM Beach Russ RP w/5 HP motors, Leiman 105 CFM, Dorr Oliver 200 CFM-piston

DRYERS—ROTARY—24"x22', 3'x24', 4'x40' 5'x50', 7'x58', all w/motor drives.

MIXERS—New 3 qt. sigma/jacketed, 5 gal. Bramley 5 HP vac./jack., 12 gal. sigma, 22 cu. ft. ribbon blender.

E. W. LAWLER has stopped piloting International Jet Liners—Full time super service now for YOU.

MIKRO BANTAM w/vari feed drive, 4TH Mikro (unused) w/Mikro collector & 3x5 Tyler screens for closed circuit.

LAWLER COMPANY

Durham Ave. Liberty 9-0245 Metuchen, N. J.

CIRCLE S ON READER SERVICE CARD

Seasons Greetings

Our most valuable offering this month is our heart-felt gratitude & thanks for your Patronage and Friendship.

May you have a successful and Happy New Year

CHEMICAL & PROCESS MACHINERY CORP.
50-52 9th St., Brooklyn 15, N.Y. HY-9-7200

CIRCLE P ON READER SERVICE CARD

COMPRESSORS

No better values at any price

110 CFM	3000 PSI	Ing. GC 50BW
138 CFM	100 PSI	7x7, Ing. ES, CP & Joy
288 CFM	100 PSI	9x9 Ing. Worth. CP
311 CFM	1500 PSI	10½-7½-3½x13 IR-ES3
351 CFM	350 PSI	11-5x11 CP TCB-2
364 CFM	100 PSI	10x9 Joy WG 9
465 CFM	100 PSI	12x11-IR-ES CP.T, Worth HB
502 CFM	125 PSI	12x13 Worth HB
686 CFM	100 PSI	14x13 Ing. ES
800 CFM	100 PSI	14½-9x7 Ing. XLE
877 CFM	125 PSI	17-10½x14 IR. XRB
1050 CFM	60 PSI	13-13x12 IR-XRE
1055 CFM	110 PSI	18-11x12 CP-OCE
1351 CFM	125 PSI	18½-11½x8½ Worth Y
1545 CFM	110 PSI	21-13x14 Ing. XRE
1665 CFM	(actual) 100 PSI	C300-300H Fuller
2520 CFM	125 PSI	17-10¾x9 Clark CMA-4L

AMERICAN AIR COMPRESSOR CORP.

Chem. Road, North Bergen, N.J. UNion 5-1397

CIRCLE T ON READER SERVICE CARD

OVER 5,000 MACHINES IN STOCK

FOR EVERY INDUSTRY AND PURPOSE

- Wrappers
- Packaging machines
- Cartoning machines
- Fillers
- Labelers
- Filter presses
- Roller mills
- Mixers
- Pulverizers
- Grinders
- Dryers
- Sifters
- Cappers
- Tablet machines

TELL US YOUR REQUIREMENTS

Complete Details And Our Special Low Bargain Prices Available On Request

UNION STANDARD EQUIPMENT CO.

318-322 Lafayette St., New York 12, N. Y.
Phone: Canal 6-5333-4-5-6

CIRCLE N ON READER SERVICE CARD

IMMEDIATE DELIVERY

CENTRIFUGE: Sharples Super Decanter, S/S Model [illegible] 14.
FILTER: [illegible]ara Style 8 horizontal type; Sparkler Models 14-[illegible] 33 D-7; 3326 R.
MILLS: Rotary cutters; J. B. Sedberry 4 WDC; Gruendler No. 1 Supermaster; Mikro 2 TH; Prater Blue Streak
MIXERS: Baker Perkins 300 Gal. with hydraulic tilt and self contained with hydraulic pump; 4,000# Grede & Gray horizontal ribbon blender; Hobart Mixanette, laboratory size; J. P. Devine 300 gal. jacketed for 100 psi.
PRESSES: 150 ton Stokes Hydraulic & Toggle presses; Colton 3 RP and 4½ T; Bolling hydraulic press.

AARON EQUIPMENT CO

9370 Byran Street
Schiller Park, Illinois
Gladstone 1-1500

CIRCLE Q ON READER SERVICE CARD

PROFIT SAVERS

STAINLESS PILOT CENTRIFUGE

In Stock

Bird 12" dia suspended solid basket Stainless Steel Centrifuge with 2 HP 3500 RPM motor directly connected. Vapor tite construction, complete with skimmer and plow.

JUST LIKE NEW

MACHINERY AND EQUIPMENT CO.

123 Townsend St. · San Francisco 7, Calif.

CIRCLE U ON READER SERVICE CARD

Stop fencing around Decide on GELB

CHEMICAL PROCESS EQUIPMENT

2—Bonnet rotary kilns, 8' x 115', complete
1—Bonnet rotary cooler, 8' x 50', complete
1—Raymond 2 roll high side roller mill
1—Stewart Bolling 8" x 16" 2 roll chrome plated rubber mill

AUTOCLAVES, KETTLES AND REACTORS

2—Pfaudler type 316 SS jacketed kettles, 100 and 200 gals.
1—Patterson type 304 SS jacketed autoclave, 10 gal. with agitator and drive, 600 psi internal, 175 psi jacket
1—Pfaudler glass lined 750 gal. jacketed reactor, Series 1 EL, complete with agitator and drive
1—Vertical type 347 SS storage tank, 8200 gal.
1—Steel 1200 gal. vertical pressure tank, 150 psi
1—Oat 10 gal. type 316 SS jacketed autoclave, 150# internal pressure and jacket, complete with agitator and drive and Dowtherm unit
2—Monel 2500 gal. jacketed autoclaves, 175# jacket and internal pressures
2—Struthers Wells type 316 SS reactors, 2000 gal. complete with agitators and drives
2—Blaw-Knox 600 gal. steel reactors, complete with double motion agitators and drives, 50# jacket, 50# internal
1—Patterson SS 40 gal. jacketed reactor, complete with agitator and drive, 50# jacket and 50# internal
1—Van Alst 250 gal. SS jacketed kettle, complete with SS column and condenser
10—Pfaudler glass lined jacketed reactors, 30 to 750 gal.

DRYERS

1—American 42" x 120" double drum dryer, ASME, N.B. complete with drives and motors
1—Allis Chalmers SS 6' x 50' rotary dryer, complete
10—Allis Chalmers rotary dryers, 6' x 50' and 7' x 60'
3—Link Belt steel roto louver dryers, Model 207-10, 310-16, 604-20
1—Hersey SS rotary dryer, 3' x 21'
1—Buflovak SS jacketed rotary vacuum dryer, 3' x 15'
1—Proctor & Schwartz SS apron dryer, 2' x 20'
3—Buflovak steel jacketed rotary dryers, 3' x 15', 5' x 20', 5' x 35'
1—Traylor 4' x 40' rotary dryer
1—Stokes Model 59DS steel rotary vacuum dryer, 5' x 30'
1—Western Precipitation Corp. S.S. pilot plant spray dryer, Type N-2
1—Bowen SS pilot plant spray dryer
2—Buflovak SS rotary vacuum dryers, 5' x 30'
2—Stokes single door vacuum shelf dryers with 6 shelves, 24" x 36"

FILTERS

3—Dorrco rubber covered filters, 6' x 2'
12—Sweetland #12 filters with 72 SS leaves
1—Niagara SS filter, Model 510-28
1—Oliver horizontal filter, 3'
1—GATX SS pilot plant filter, 2' x 6"
1—Oliver SS rotary vacuum pressure precoat filter, 5'3" x 8'
1—Oliver SS rotary vacuum filter, 3' x 4'
1—Shriver aluminum 30" x 30" P&F filter press, 30 chambers
10—Shriver plate and frame filter presses, 12" to 42"

THE GELB GIRL—DECEMBER 1960

CENTRIFUGES

1—Fletcher 48" SS under-driven centrifuge, complete with perforate basket and motor
1—AT&M 48" suspended type centrifuge, complete with plow, motor and imperforate basket
7—Western States 40", type 316 SS, suspended type centrifuges, complete with perforate baskets, plows and 40 HP motors
2—Fletcher 40", rubber covered, under-driven centrifuges with perforate baskets and motors
1—AT&M type 316 SS suspended type centrifuge, complete with 26" perforate basket, plow and motor
4—Tolhurst 40" center slung rubber covered centrifuges, with perforate baskets and motors
3—Tolhurst 30" center slung, rubber covered, centrifuges, with perforate baskets and motors

MIXERS

1—Robinson SS 125 cu. ft. horizontal double ribbon blender
1—Cleveland SS double cone blender, 85 cu. ft. complete with drive and motor
2—Sturtevant #7 dustite rotary batch blenders, NEW
15—Robinson type 304 SS horizontal blenders, 255 cu. ft.
1—Baker Perkins Size 16, Type UUEM, 150 gal., jacketed double arm dispersion type mixer, complete with compression cover and 100 HP motor
1—Baker Perkins 20 gal. SS jacketed vacuum double arm mixer
1—Stokes SS granulating mixer, Model 21-J

MISCELLANEOUS

1—Vulcan SS bubble cap column, 4' x 25 plates
1—Badger type 316 SS bubble cap column, 42" dia. with 11 trays
1—Badger type 316 SS bubble cap column, 36" dia. with 8 trays
1—Struthers Wells type 316 SS heat exchanger, 330 sq. ft.
1—Condenser Service type 316 SS heat exchanger, 350 sq. ft.
3—Badger type 316 SS heat exchangers, 500 and 600 sq. ft.
1—Downington type 316 SS heat exchanger, 750 sq. ft.
1—Griscom Russell stainless steel heat exchanger, 900 sq. ft.
4—Patterson type 316 SS condensers, 200 and 300 sq. ft.
4—Davis Engineering Carpenter 20 heat exchangers, 125 sq. ft. NEW
20—Davis Engineering SS heat exchangers, 102, 119, 136 and 166 sq. ft. NEW
2—Swenson type 316 SS vacuum crystallizers, 3' 6" x 12', 2' x 12'
1—Mikro #1SH pulverizer, complete
3—Williams type 316 SS hammermills, Model AK
1—Ross 6" x 14", 3 roll paint mill, complete

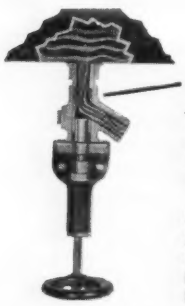
1—Type 316 SS 8" x 12' bubble cap column with 14 trays
2—Struthers Wells type 316 SS jacketed reactor, 2000 gal.
1—Blaw-Knox 300 gal. SS vacuum reactor
1—Patterson Kelley twin shell blender, 150 cu. ft.

R. GELB & SONS, INC.
U. S. HIGHWAY 22, UNION, N. J. · MURDOCK 6-4900
75 ANNIVERSARY

CIRCLE V ON READER SERVICE CARD

NEW STRAHMAN SAMPLING VALVE CANNOT CLOG

1. In closed position stainless steel piston fills whole interior of valve — extends to inner surface of vessel — therefore foreign material cannot gather in body.



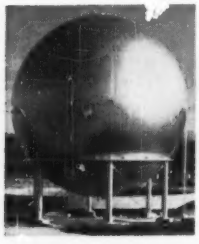
2. In open position piston retracts, leaving entire body empty for FREE-FLOWING LIVE SAMPLE.

Perfect sealing is assured by two compressible, replaceable Teflon rings.

These Sampling Valves are designed for simple installation in existing systems, merely by welding a ¾" half coupling into the pipe or vessel, from which samples are required.

PD-794

STRAHMAN VALVES, INC.
Nicolet Ave., Florham Park, N.J.



Gas Holders

Welded aluminum tanks, pressure vessels and processing equipment for the chemical and processing industries.

Conventional or special design tanks, shop built or field erected, with flat, flanged and dished or hemispherical heads; built to your specifications, and also to ASME Code Requirements.

Send us your inquiries for elevated tanks, chemical and processing equipment for aluminum, stainless and carbon steel, Monel and other alloys. Write for "Tank Talks."

Established 1854

R. D. COLE MANUFACTURING CO.
COLE
NEWNAN, GEORGIA

Index of Advertisers

Adams Co., R. P. 160
Aerofin Corp. 159
Aldrich Pump Co. 24
Allied Chemical Corp.
General Chemical Div. 39
Nitrogen Division 55
Alloy Steel Products Co. 122
Aluminum Co. of America
Chemicals Div. 57
American Cyanamid Co. 22-23
American Instrument Co. 120
Amercoat Corp. 115
Appleton Electric Co. 1

Bird Machine Co. 2

Clarage Fan Co. 66
Cole Co., R. D. 168
Consolidated Vacuum Corp. 157
Continental-Emsco Co., Div. of
Youngstown Sheet and Tube Co. 61
Cook Co., C. Lee 4
Corning Glass Works 28
Crouse-Hinds Co. 32

Darling Valve & Mfg. Co. 128
Dean Products, Inc. 161
DeLaval Separator Co. 58-59
DeZurik Corp. 78
Dow Corning Corp. 124
Ducon Company 161
Duriron Company, Inc., The 113

Englehard Industries, Inc. 67

Falcon Manufacturing Div.,
First Machinery Corp. 125
Forge & Fittings Division of
H. K. Porter Co., Inc. 126
Foxboro Co. 69
Friedrich Uhde GMBH 24-A

Glascote Products, Inc. 81

Hardinge Co. 154
Hercules Powder Co. 109

Industrial Filter & Pump Mfg. Co. 47
International Nickel Co. 45

Jenkins Bros. .....
Joy Manufacturing Co. .....

Lawrence Pumps, Inc. 1
Layne & Bowler, Inc. .....
Link-Belt Co. .....

Manton Gaulin Mfg. Co. .....
Marathon Division of
American Can Co. 1
McGraw-Hill Publishing Co., Inc. 16-1
2
Minnesota Mining & Mfg. Co. 14-1
Mixing Equipment Co. ...Fourth Cove
Mobil Oil Company 6-

National Carbon Co., Div. of
Union Carbide Corp. 8, 3
National Engineering Co. .....
NETTCO Corporation 11
Niagara Blower Co. 12

Pfaudler Co., Div. of
Pfaudler-Permutit, Inc. 34-3
Pittsburgh Lectrodryer Div. of
McGraw-Edison Co. 15
Powell Valves, Wm. Powell Co. 18-1
Prater Pulverizer Co. 16
Pressed Steel Tank Co. 1

Quaker Oats Co.
Chemical Division 5

Reliance Electric & Engineering
Co. 133-13
Rockwell Manufacturing Co.
Nordstrom Valves Div. 26-2

Sargents Sons Corp., C. G. 13
Sharples Corp. 119, 121, 12
125, 127, 12
Shell Chemical Co. .....Second Cove
Spray Engineering Co. 13
Strahman Valves, Inc. 16
Sturtevant Mill Co. 12
Sun Shipbuilding & Dry Dock Co. 2

Taber Pump Co. 12

U. S. Industrial Chemicals Co.,
Div. of National Distillers &
Chemicals Corp. 29-30
U. S. Steel Corp.
Alloy (UCO) 20-21

Vogt Machine Co., Henry..... 8

Wallace & Tiernan, Inc. 11
Westinghouse Electric Corp. 9-1
Wilfley & Sons, A. R. .....Third Cove
Wyandotte Chemicals Corp.
Michigan Alkali Div. 71-7

Advertising Sales Representatives

Atlanta 9 ..... R. K. Burnet
1375 Peachtree St. N.E., TRinity 5-0523
Boston 16 ..... A. S. Reed
McGraw-Hill Bldg., Copley Square, COngress 2-1160
Chicago 11 — Gene Davis, J. M. Rodger, Jr.
520 N. Michigan Ave. MOhawk 4-5800
Cleveland 13 ..... John G. Mitchell
55 Public Square SUperior 1-7000
Dallas 1 ..... Robert T. Wood
Vaughn Bldg., 1712 Commerce RIverside 7-9721
Denver 2 ..... John Patten
1700 Broadway ALpine 5-2981
Detroit 26 ..... Chas. M. Crowe, Jr.
856 Penobscot Bldg. WOodward 2-1793
Frankfurt/Main ..... Stan Kimes
85 Westendstrasse
Geneva ..... Michael R. Zeynel
2 Place du Port
Houston 25 ..... Gene Holland, John Grant
W-724 Prudential Bldg. JAckson 6-1281
London EC4 .. E. E. Schirmer, Edwin E. Murphy
95 Farringdon St.
Los Angeles 17 ..... John B. Uphoff
1125 W. Sixth St. HUntley 2-5450
New York 36 — R. G. Frederick, A. L. Gregory, John R. Emery
500 Fifth Ave. OXford 5-5959
Philadelphia 3 ..... E. M. Schellenger
6 Penn Center Plaza LOcust 8-4330
Pittsburgh 22 ..... G. S. Ryan
4 Gateway Center EXpress 1-1314
Portland 4 ..... Scott B. Hubbard
Room 445, Pacific Bldg. CApitol 3-5118
St. Louis 8 ..... J. M. Rodger, Jr
3615 Olive Street JEfferson 5-4867
San Francisco 4 ..... R. T. Koch
68 Post St. DOuglas 2-4600

Professional Services 16

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

EMPLOYMENT OPPORTUNITIES 16
EQUIPMENT
(Used or Surplus New)
For Sale 162-16
WANTED
Equipment 16

ADVERTISERS INDEX

Aaron Equipment Co., Div. of Areco Inc.. 16
American Air Compressor Corp. 16
Brill Equipment Co. 16
Bristol Co., The 16
Butler Manufacturing Co. 16
Chemical & Process Machinery Co. 16
Equipment Clearing House Inc. 16
Esquire Personnel 16
Fairchild Engine & Airplane Co. 16
First Machinery Corp. 16
Gelb & Sons, Inc., R. 166, 16
Heat & Power Co., Inc. 16
Lawler Co. 16
Little Co. Arthur D. 16
Loeb Equipment Supply Co. 16
Machinecraft Corp. 16
Machinery & Equipment Co. 162, 163, 16
Perry Equipment Corp. 164, 16
Scheurs Atomiseurs Co. 16
Southern Foundry Supply Inc. 16
Stein Equipment Co. 16
Union Standard Equipment Co. 16
Triangle Publications Inc. 16

WILFLEY
ACID PUMPS

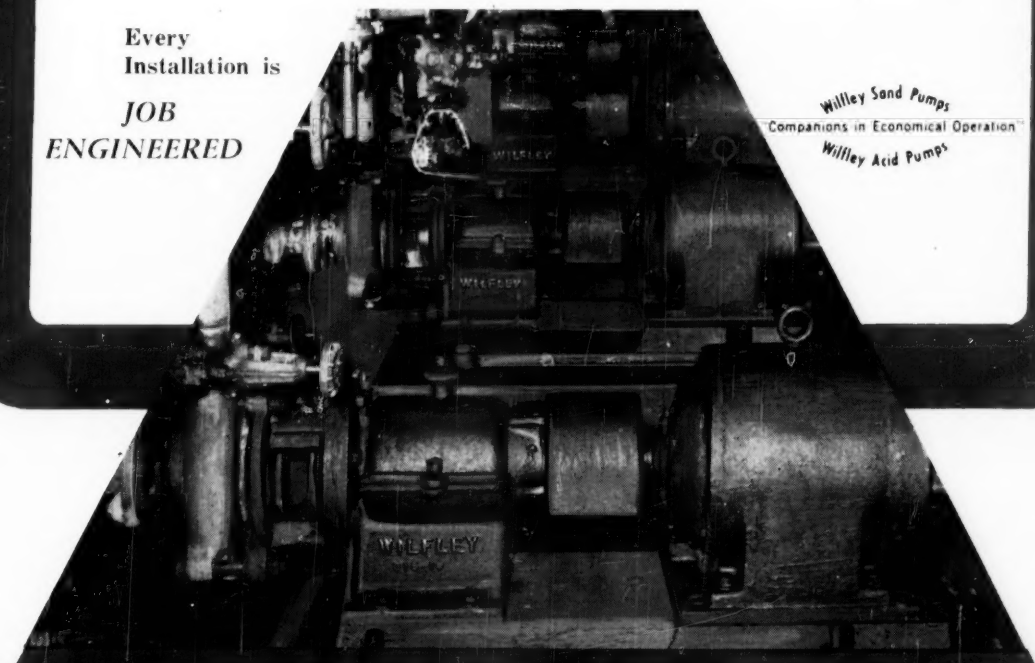
Continuous, Low Cost Service

Twenty-four hour, maintenance-free operation is one big reason why Wilfley Acid Pumps consistently give you lower pumping costs. Add to this Wilfley's low installation cost, packingless design, longer pump life, plus higher output, and you have maximum pumping economy.

A wide range of corrosive applications can be covered with a variety of metal alloys as well as plastic. 1″ to 8″ discharge sizes are available with 10 to 3000 GPM capacities and heads up to 200′ and higher. Write, wire or phone for complete information.

Every Installation is *JOB ENGINEERED*

Wilfley Sand Pumps
Companions in Economical Operation
Wilfley Acid Pumps



A. R. WILFLEY and SONS, INC.

Will you reap the long-term payoff of good mixer shaft sealing?

If you want to minimize your mechanical fluid mixing costs, take a hard look at *mixer shaft sealing.*

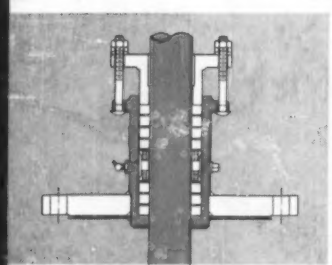
This is the area where profits can leak away unnoticed. The right shaft seal makes all the difference between an efficient mixing operation and a ruinously expensive one.

When you're aiming for low-cost shaft sealing, *don't be fooled* by low first cost. Instead, look for solid long-range savings you can make in terms of *smooth operation, rapid maintenance, minimum downtime.*

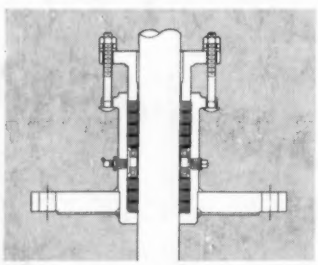
Here are some mechanical reasons why you get these savings with LIGHTNIN Mixers. Every one of the features illustrated below is a LIGHTNIN "first." Many are yours only with LIGHTNINS. And only LIGHTNINS give you *all* of them!

For lowest-cost fluid mixing, see your LIGHTNIN Mixer representative soon. Look him up in Chemical Engineering Catalog. Or write us direct.

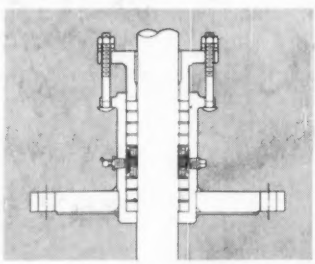
How you cut mixing cost with the *Lightnin* stuffing box



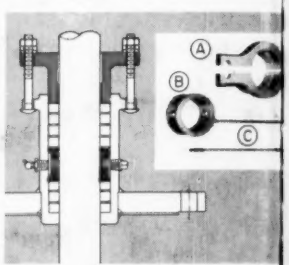
1. SAVE COST of a special-alloy mounting flange with all-welded LIGHTNIN construction. Forged steel flange is faced with correct alloy for your process conditions. Hub is solid alloy. Alloy parts are shown in color.



2. GET SUPERIOR SEALING with 7 rings of large-cross-section packing. Separators facilitate packing removal, distribute force uniformly. Gland bolts, threaded part way, prevent overtightening.



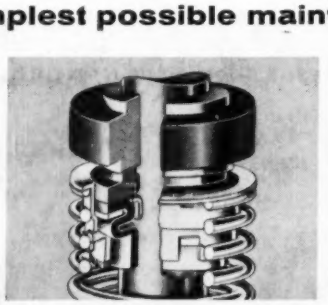
3. GET BETTER LUBRICATION without repacking. Lantern ring evenly distributes lubricant; permits continuous lubrication under pressure; extends time between repackings. Relief plug prevents overlubrication.



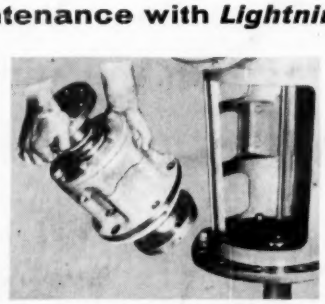
4. REPACK FASTER with exclusive split packing gland (A) that comes right off the shaft to allow maximum work space. Lantern ring (B) lifts out quickly by means of pullers (C), standard accessories.

Get simplest possible maintenance with *Lightnin* mechanical seal

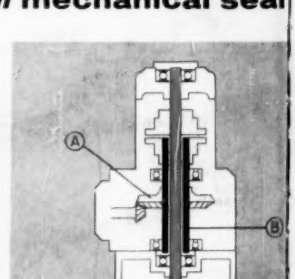
1. ELIMINATE REPACKING and adjustment with this cartridge-type LIGHTNIN rotary mechanical seal assembly, optional on all LIGHTNIN Mixers. It's saving many users thousands of maintenance dollars a year.



2. GET WIDEST CHOICE of seal designs and materials to meet your conditions: stainless steels, Stellite, Hastelloy alloys, bronze, ceramic, Teflon, etc. Handle pressures to 2500 psig and all temperature ranges.



3. REPLACE SEAL ASSEMBLY quickly, if ever necessary—without dismantling mixer or removing it from tank, and *without skilled manpower.* Seal cartridge unbolts, comes out as a unit; replacement bolts in.



4. RETAIN GEAR ALIGNMENT when changing seal. Mixer gears (A) are isolated from shaft by hollow drive quill† (B) —*cannot get out of line* when seal is removed. Shaft realignment is automatic on reassembly.

†patented

WHAT MIXING OPERATIONS are important to you? You'll find a wealth of information on fluid mixing in these helpful bulletins describing LIGHTNIN Mixers:

- ☐ Top or bottom entering; turbine, paddle, and propeller types: 1 to 500 HP (B-102)
- ☐ Top entering; propeller types: ¼ to 3 HP (B-103)
- ☐ Portable: ⅛ to 3 HP (B-108)
- ☐ Side entering: 1 to 25 HP (B-104)
- ☐ Laboratory and small-batch production types (B-112)
- ☐ Condensed catalog showing all types (B-109)
- ☐ Quick-change rotary mechanical seals for pressure and vacuum mixing (B-111)
- ☐ Confidential data sheet for figuring your mixer requirements (B-107)

Check, clip and mail with your name, title, company address to:

MIXING EQUIPMENT Co., Inc., 128-n Mt. Read Blvd., Rochester 3, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 19, Ont.

Lightnin® Mixers™

MIXCO fluid mixing specialists

*patent pending

Chemical Engineering

J. ELTON TUOHIG
Publisher

CECIL H. CHILTON
Editor-in-Chief

In August 1946 *Chemical & Metallurgical Engineering* was renamed *Chemical Engineering*. *Chemical & Metallurgical Engineering* was the successor to *Metallurgical & Chemical Engineering*, which, in turn, was a consolidation of *Electrochemical & Metallurgical Industry* and *Iron & Steel Magazine*. The magazine was originally founded as *Electrochemical Industry*.

McGRAW-HILL PUBLISHING COMPANY, INC., NEW YORK CITY

Volume 67

January to December 1960

GENERAL ALPHABETICAL INDEX

A

Absorption
Absorbents—new absorbents cut H_2S removal cost (chart).....Dec. 26 44
Absorption with chemical reaction—report. A. J. Teller (charts & tables) July 11 *111
Review mass transfer concepts—CE Refresher. Coates & Pressburg
Analyze absorption in gas separations Oct. 3 99
How to design packed-tower absorbers .....Oct. 31 109
Acetic acid—Submerged fermentation yields low-cost acetic acid in Taiwan (chart) (N) .....Sept. 5 50
Acetylene
Chemicals from methane—source and end use. Messing & Bradley (tables) June 27 76
Czech process claims highest yield (N) Mar. 7 62
High-pressure acetylene chemicals at GAF's Calvert City, Ky., plant Feb. 22 112
Transmission system design—safety aspects (charts).....Sept. 5 *131
Two-stage a.c. electric arc process boosts acetylene yields (N)..Nov. 14 120
Acid chlorides.....Dec. 12 100
Acids
Corrosive-acids heater. R. T. Gaudlitz (D.N.) .....Sept. 19 *214
Peracetic acid route engenders new epoxide compounds.....Aug. 22 *78
Peracetic acid route to epoxides gets ultimate safeguards at Carbide plant (charts) (N).....July 25 *68
Waste acid treatment—know which alkalis save money. H. L. Jacobs (charts) .....May 30 *87
Waste acids neutralized by clam shells (N) .....June 13 *78
Waste pickle liquor acid regenerated by new mercury cell process (chart) (N) .....May 16 82
Adhesives
Adhesive prevents slippage of palletized polyethylene bags.....Mar. 7 80
Aluminum foil with adhesive coating May 30 64
Cementable Teflon.....Nov. 28 96
Dextrin—borated dextrins produce stable adhesives.....Oct. 31 *72
Epoxy adhesive.....Jan. 11 *60
Epoxy-glue pipe joint avoids expensive welds .....Nov. 28 *163
Nylon "welded" to metal with epoxy bonding agent.....Oct. 3 64
Silica sol forms an unusually strong bond .....Feb. 22 82
Thermosetting film adhesive for aircraft parts welding.....Nov. 14 *136
Adsorption
Activated alumina for gas drying. Dieter Janchen (charts).....Oct. 31 115
Fixed-bed adsorption—report. H. M. Barry (charts & tables).....Feb. 8 *105
Haines sulfur recovery process goes into pilot plant (N).....Dec. 12 *86
Agitation
Corrosion-control design. N. H. Parker
Guides to reducing agitator failures Dec. 12 *190
Fabrication: key to mixer corrosion Dec. 26 *112
Film coefficients of heat transfer for agitated process vessels. E. J. Ackley (charts & tables).....Aug. 22 133
Agricultural Chemicals
Apple freshness prolonged with growth regulator .....Sept. 5 74
Asphalt spray prevents evaporation of water from seeded soil.....May 30 *68
Forage preservative .....Mar. 21 104
Growth retarder reduces nursery losses Sept. 19 110
Herbicide, Avadex, safely combating wild oats .....Jan. 25 68
Herbicide, called Dacthal, offers superior control of crabgrass.....Feb. 22 78
Miticide for use on fruit trees..May 16 *94
Monsanto's Barton Plant computer control increases NH_3 output at Luling, La. complex (N).....Nov. 14 *110
Mulch—elastometric spray.....Apr. 18 112
Mulch—polyethylene mulch speeds tree development .....Apr. 4 *92
Poultry disease preventitive...July 25 80
Sprays improved by nonionic emulsifiers Mar. 7 78
Air Conditioning—Pump balances space heat in new facility (N) (chart) Mar. 7 61
Alcohol
Ethyl alcohol—Ethylene copes with competition. Messing & Bradley (table) .....Aug. 22 76
Oleyl alcohol isomer in gas chromatography .....Dec. 26 63
Secondary alcohols yield ketones in catalytic liquid process (N)....Feb. 8 *63
Alkalis
Clam shells kill waste acid (N) .....June 13 *78
Know which alkalis can save money in waste acid treatment. H. L. Jacobs (charts) .....May 30 *87
Alum—Liquid alum goes continuous at Chemico (N) .....Nov. 14 116
Alumina
Activated alumina for gas drying. Dieter Janchen (charts).....Oct. 31 115
Alloy improves alumina applications Aug. 8 76
Alumina excels conventional potting compounds .....Jan. 25 *72
Bayer process—new ideas refresh alumina process at Kaiser Aluminum & Chemical plant—flowsheet. Chopey & Arnold, Jr.....Nov. 28 *108
Ceramic brick.....Feb. 8 78
Four high-purity alpha and gamma aluminas .....Jan. 11 62
Missile nose cones made from Al_2O_3 ceramics .....Apr. 4 *90
Aluminum
Adhesive-coated foil bonds to many materials .....May 30 64
Aluminum alloys for low-temperature construction. E. W. Johnson (charts & tables).....Aug. 8 *133
Aluminum coating furnace-bonded for more uniformity.....Feb. 22 *80
Anodizing—Kaiser's new process colors aluminum sheet (N).....May 2 66
Automotive market consuming more aluminum .....Aug. 8 72
Barges—first, large all-aluminum barge coming .....Aug. 22 166
Process shakeup brewing (chart) (N) Oct. 17 90
Underground fueling system for jet aircraft uses largest aluminum pipe Nov. 28 *164
American Institute of Chemical Engineers
Fairfield County, Conn., directory of firms related to chemical engineering Oct. 3 *127
52nd annual meeting (N).....Jan. 25 54
Ammonia
Chemicals from methane—source and end use. Messing & Bradley..June 27 74
Monsanto's Barton Plant raises NH_3 output in big computer test (N) Nov. 14 *110
U. S. ammonia feels foreign impact. J. A. King (chart & tables)..July 11 *82
Argon—Industrial gases ride technology boom. J. B. Bacon (charts & table) Jan. 11 *54
Aromatics see Petrochemicals
Asphalt
Asphalt spray prevents evaporation of water from seeded soil.....May 30 *68
Rubberizing powders add strength Oct. 17 112
Atomic Power
Antarctic to get first "profitable" reactor (N).....Dec. 12 78
Atomic fuel processing
Pt 2 Hanford, atoms for peace (chart) .....Jan. 11 *113
Pt 3 Idaho Falls: atoms in the desert Jan. 25 *105
Pt 4 Savannah River does it cheaper Feb. 22 *135
Pt 5 Oak Ridge: home of the bombs (charts) .....Mar. 7 *137
Atomic waste disposal by foaming backed by AEC (N).....Aug. 8 68
Atomized suspension technique (ANT) treats municipal sewage sludge in Quebec (N).....Jan. 25 *56
"Entropy trapping" and "picket fences" (N) .....Jan. 25 58
Generator — portable, high-voltage, atomic generator developed by Soviet (N) .....Apr. 18 92
Heavy water—first private production planned (N).....Oct. 17 94
Heavy water process from Britain shaves costs (chart) (N)....Sept. 19 92
Incinerator cuts cost of atom-waste disposal (N).....Aug. 22 *56
Inventory of new plants and facilities Apr. 18 172
Inventory of new processes and technology .....May 2 112
Japan takes a plunge into atomic power (N) .....Feb. 22 70
New York's ADO plans state's atomic future (N).....June 13 82
Nuclear energy makes progress slowly —60's challenge report.....Jan. 11 93
Nuclear fuel advances may improve A-power economics (N).....Aug. 22 56
Nuclear mining could lower sulfur cost (N) .....June 27 66
Prospects for nuclear process heat. Wright & Smith.....Nov. 28 *123
Radioactivity—minimizing radiation hazards. L. J. Cherubin....June 27 *105
Reactors—organic-cooled nuclear reactors make new gains (N).....May 16 84
Reactors reach out to conquer space (N) .....May 16 84

NOTES—(D.N.) Design Notebook; *Illustrated; (N) News; (P.N.) Plant Notebook

Automation
Moscow control conference—First Congress of International Federation of Automatic Control. Ernest Conine Sept. 19 *181
Salt—new process automates salt refining (chart) (N).....Oct. 31 *49
Special-purpose speeds mix formula calculating for H. P. Hood & Sons (N) Nov. 28 *84
Sugar refinery melt house designed for automatic flow—flowsheet.....May 2 *94

B

Batch Operations
Chart speeds calculation of economic batch size. H. C. Schweyer (P. N.) (chart).....Sept. 5 152
For batching use hydraulic paradox. A. W. Billitzer (P. N.).....Jan. 25 122
Minimize batch equipment cost. S. E. Ketner (chart & table).....Aug. 22 121
Benzene
Oil-based aromatics gain first place. Messing & Bradley (tables)..Dec. 26 50
Oil refiners rush to produce aromatics (table) (N).....Oct. 17 100
Pipeline designed to prevent severe winter freezing (N).....F b. 8 *70
Source—new process shifts from coal to petroleum (N).....June 13 82
Beryllium
Beryllium-oxide ceramics conduct heat but not electricity.....July 11 *166
Fluoride route to high-purity beryllium at Brush Beryllium—flowsheet Oct. 31 82
Bleaching—Bleach process—continuous controlled system improves bleach uniformity (chart) (N).....June 27 *64
Blending—Solid-solid blending—report. J. J. Fischer (charts).....Aug. 8 *107
Book Reviews
Adhesive bonding of reinforced plastics. H. A. Perry, Jr.....Feb. 22 193
Automation, cybernetics and society. F. H. George.....Mar. 7 192
Careers and opportunities in chemistry. Philip Pollack.....June 13 269
Capsule reviews
Chemicals and materials—new monographs .....Oct. 3 150
Processes and practices—new handbooks and references.....Oct. 31 167
The corrosion and oxidation of metals. U. R. Evans.....June 13 268
Cost engineering in the process industries. C. H. Chilton.....Sept. 5 150
Dictionary of automatic control. R. J. Bibbero .....Oct. 17 256
Elements of ion exchange. Robert Kunin .....May 30 139
Encyclopedia of chemical technology—second supplementary volume ed. A. Standen.....Nov. 14 286
Engineering economics for professional engineers' examinations. Max Kurtz Aug. 22 188
Executive recruiting—How companies obtain management talent....Dec. 12 224
Fluidization. Max Leva.....Jan. 25 154
Fluidization and fluid-particle systems. Zenz & Othmer.....Sept. 19 256
Frequency response for process control. W. I. Caldwell & others.....Mar. 21 214
Gas chromatography. A. I. M. Keulmans .....Jan. 11 172
Gmelin's handbook—eighth edition. Alphabetic series to systematic subject index; Magnetic materials; Cadmium, supplement volume; Fluorine, supplement volume; Silicon, part B; Silicon, part C.....July 11 190
Handbook of chemistry and physics. 42nd ed. Ed. by C. D. Hodgman & others .....Dec. 26 129
High-resolution nuclear magnetic resonance. Pople, Schneider & Bernstein Feb. 22 192
Hbt organic coatings. R. B. Seymour May 16 206
Industrial instrument servicing handbook. G. C. Carroll.....May 2 172
Information extra.....Nov. 28 184
Introduction to chemical engineering thermodynamics. Smith & Van Ness Apr. 18 253
Introduction to matrix analysis. Richard Bellman.....Sept. 5 192
An introduction to the organic chemistry of high polymers. C. S. Marvel May 30 139
Linear and stereoregular addition polymers: polymerization with controlled propagation. Gaylord & Mark..Feb. 8 *177
Nuclear magnetic resonance—applications to organic chemistry. J. D. Roberts .....Feb. 22 193
Of mice, men and molecules. J. H. Heller .....Aug. 8 176
Organic sequestering agents. Chaberek & Martell.....Apr. 18 252
Organic syntheses, Vol. 39. Ed. Max Tishler .....Jan. 25 156
Plastic application series ed. H. R. Simons. Polyester resins, J. R. Lawrence; Acrylic resins, M. B. Horn; Metallizing of plastics, Harold Narcus June 27 176
Polymers and resins. Brage Golding Apr. 4 *202
Principles and practice of gas chromatography. Ed. R. L. Pecsok..Jan. 11 172
Process engineering calculations. Mack Tyner .....July 25 174
Reaction kinetics for chemical engineers. S. T. Walas.....Mar. 21 212
The right approach for job searchers. E. A. Butler.....Dec. 12 227
S-Triazines and derivatives. Smolin & Rappoport .....Mar. 7 193
Story of engineering. J. K. Finch Sept. 19 256
Writing in industry. Siegfried Mandel Oct. 17 258
Boron-fuel status changed (N)..Jan. 11 44
Bromine—Corrosion—moisture: key to bromine corrosion. Lake & Gunkler Oct. 31 *136
Bubble Caps
Entrainment from perforated bubble trays at close spacings. L. Friend & others (charts & tables)....Oct. 31 101
Retraying bubble cap columns. James Tipton (charts & table).....July 25 *134
Butadiene
European firms enter natural-synthetic rubber (N).....Aug. 22 56
Propylene sires new hopefuls. Messing & Bradley (tables).....Sept. 5 68

C

Calculations
Air—chart finds volume or density. J. A. Seiner (D. N.).....Mar. 7 *158
Azeotropic and extractive distillations—report. Jesse Coates .....May 16 *121
Better use for control charts. E. S. Aldredge .....Jan. 25 *95
CE Refresher see under **"Chemical Engineering Refresher"**
Control design—Systems engineering. T. J. Williams (charts).....Oct. 17 *181
Distillation tower calculations—computer offers better solution of multicomponent system. A. M. Peiser (tables) .....July 11 *129
11 quick tests for data consistency. B. C.-Y. Lu.....Oct. 3 *105
Entrainment from perforated bubble trays at close spacings. L. Friend & others (charts & tables).....Oct. 31 101
Estimate engineering properties. W. R. Gambill (charts & tables)
Calculate engineering properties Jan. 11 109
Evolutionary operation can optimize your chemical process. J. S. Hunter (charts & tables).....Sept. 19 193
Film coefficients of heat transfer in agitated systems. E. J. Ackley..Aug. 22 133
Graphical method aids constant rate filtration scaleup. White & Hyman June 13 *219
Heat transfer see under **Heat Transfer**
How statistics apply to chemical processes. T. L. Koehler.....Dec. 12 142
How to evaluate interactions. C. A. Zapata (D. N.) (charts).....Apr. 4 160
How to predict ternary azeotropes. Imrich Klein.....Nov. 14 233
Interpreting dimensionless groups. L. C. Tao.....Nov. 28 129
Mass transfer operations see under **"Chemical Engineering Refresher"**
Nomographs help find tank diameter. Leon Green (D. N.).....Feb. 8 143
Correction .....Apr. 18 198
Process kinetics can predict reaction mechanism. Henry Eyring (tables) Dec. 26 83
Rate of reaction—why not one expression for all reaction rates? L. S. Kowalczyk .....Oct. 17 *191
Sum-of-years depreciation. J. F. Kuong (D. N.).....Nov. 14 236
Short-cut to equilibrium plots. Ferdinand Rodriguez (D. N.).....Mar. 7 *156
Slide-rule solutions for cubic equations. Jesse Roth (D. N.)....Jan. 11 130
Some rules of thumb for quick estimations. J. Klengen (D. N.)....Mar. 7 156
Template speeds repetitive calculations. C. F. A. Roberts (D. N.) June 27 *136
Viscosities—extending data with existing charts. H. F. Reinhold, Jr. (D. N.) (chart).....Apr. 4 162
Canada—1960 engineering salary data (tables) .....Dec. 12 168
Carbon black—Masterbatch production takes off. Frances Arne (charts) Oct. 3 54
Carbon dioxide—New uses for liquid carbon dioxide as coolant mount (N) Nov. 14 132
Carbon disulfide—Chemicals from methane—source and end use. Messing & Bradley .....June 27 80
Catalysts
Cat cracker at Esso Standard shatters world on-stream record (N)..Mar. 7 *64
Cracking catalysts boost yields..May 16 94
Crystals give new insight into catalysis (N) .....Oct. 3 *46
Equations predict cracked product yields (N).....Jan. 25 52
Grace's Davison's SM-30 replaces DA-5 (N) .....July 25 66
Hydrogenation catalyst uses silk fibers as carrier (N).....Mar. 21 94
Palladium-carbon hydrogenation catalyst boasts high activity.....Feb. 22 78
Polypropylene by the Ziegler process—Humble's high activity catalyst is the key—flowsheet.....June 27 *96
Secondary alcohols yield ketones in catalytic liquid process (N)..Feb. 8 *63
Cellulose
Cellulose resin dissolves easily, is good nonionic thickener.....May 16 94
Modified cellulose for electroluminescent lamps.....Sept. 5 72
Powder, called Avicel, used in foods, paints, drugs.....Oct. 31 70
Cement—Outlook: grim but hopeful. F. C. Price (chart).....Oct. 31 *60
Ceramics
Beryllium-oxide ceramics conduct heat but not electricity.....July 11 *166
Ceramic brick.....Feb. 8 78
Ceramic-coated metals handle much higher temperatures than glassed steel (charts & table).....Oct. 3 130
Foamed ceramic shows good electrical properties .....May 2 *80
"Chemical Engineering"
Conference on the New Chemical Engineering see under **Engineering**
Welcomes new publisher. J. Elton Tuohig (N) .....Feb. 22 *68
"Chemical Engineering Cost File"
22. Process control instrumentation. Vilbrandt & Dryden.....Jan. 11 124
23. Estimating process instrumentation. J. W. Bernard.....Jan. 25 120
24. Construction equipment rental rates. C. A. Adams.....Feb. 8 146
25 and 26. Unit construction costs: Warehouses. A. R. Sellers Feb. 22 151, ...Mar. 7 152
27. Process equipment nomograph. Walas & Spangler.....Mar. 21 173
28. Welded & seamless heat exchanger tubing .....Apr. 4 156
29. Analysis of ethylene plant costs. Haselbarth & Berk.....Apr. 18 194
30. Labor factors: a.c. motor starters. E. W. Michel.....May 2 142
31. Chemical plant cost breakdown. Haselbarth & Berk.....May 16 158
32. Estimating engineering drafting costs. D. F. Brosnan.....May 30 114
33. Labor factors: centrifugal pump systems. W. R. Kane.....June 13 232
34. Labor factors: motor starters. E. W. Michel.....June 27 134
35. Estimating pressure vessels. A. J. Reilly (charts).....July 11 146
36. Plate-and-frame filters. J. L. Hutton, Jr.....July 25 132
37. Labor factors: heat exchangers. D. F. Brosnan.....Aug. 8 152
38. Labor factors: a.c. and d.c. motors. E. W. Michel.....Aug. 22 148
39. Centrifugal separators. J. C. Smith Sept. 5 148
40. Labor factors: electric panels & cabinets. E. W. Michel.....Sept. 19 208
41. Computers for cost estimating Oct. 3 119
42. Factors in cost estimating. W. F. Wroth .....Oct. 17 204
43. Storage and process tanks. W. F. Wroth .....Oct. 31 124
44 & 45: Engineering valuation. Haselbarth & Berk..Nov. 14 244, Nov. 28 146
46. Cost-capacity data. Berk & Haselbarth .....Dec. 12 172
47. Ductwork. R. T. Witherspoon Dec. 26 110
"Chemical Engineering Refresher"
Review heat transfer principles. Coates & Pressburg (charts & tables)
Match heat transfer principles to your exchanger needs.....Jan. 25 *101
How heat transfer occurs in evaporations .....Feb. 22 *139
Multiple-effect evaporators...Mar. 21 *157
Review mass transfer concepts. Coates & Pressburg (charts & tables).Sept. 5 135
Analyze absorption in gas separations Oct. 3 99
How to design packed-tower absorbers .....Oct. 31 109
Review principles of distillation. Coates & Pressburg (charts).....Nov. 28 137
Unsteady-state heat transfer. Davis & Akers. Pt 1 Apr. 18 *187, Pt 2 May 16 *151
Unsteady-state heat transfer. S. H. Davis, Jr. (tables)
Pt 3 Use numerical methods of analysis .....June 13 213
Pt 4 Use numerical mathematics July 11 135
Pt 5 Numerical mathematical analysis .....Aug. 8 *137
"Chemical Engineering Reports"
Absorption with chemical reaction. A. J. Teller (charts & tables) July 11 *111-124
Adsorption-fixed-bed adsorption. H. M. Barry (charts & tables)...Feb. 8 *105-120
Azeotropic separations. Jesse Coates (charts & tables).....May 16 *121-136

Capital cost estimates for process industries. J. W. Hackney (charts & table) Pt 1 Mar. 7 113-130, Pt 2 Apr. 4 *119-134
Containers for chemicals. T. E. Dowling (tables) ..... Oct. 3 *85-96
Flow of fluids process design. E. E. Ludwig (charts & tables). June 13 *161-208
How to prepare for plant startups. J. E. Troyan ..... Sept. 5 *107-126
Inventory of new plants and facilities (tables) ..... Apr. 18 171-182
Inventory of new processes and technology (tables) ..... May 2 103-120
Inventory—semiannual inventory of new plants and facilities. . . Oct. 17 173-180
Materials of construction—19th biennial report (tables)
Selecting materials for process piping. C. K. Aldrich ..... Nov. 14 *183
Directory of manufacturers. . Nov. 14 193
Inventory of current literature Nov. 14 214
60's challenge chemical engineers Jan. 11 *89-104
Solid-solid blending. J. J. Fischer (charts) ..... Aug. 8 *107-128

Chemical Engineers
Andrews, Eugene. Paul Hauser & E. J. Mikity ..... Apr. 18 *201
Block, Frank E. ..... Apr. 18 *204
Giacco, Alexander F. ..... Oct. 17 *198
Holbrook, George E. ..... June 13 *224
Piret, Edgar L. Arthur Erikson May 30 *107
Robbins, Martin D.—new "Chemical Engineering" western editor. . Mar. 7 *196
Tuohig, J. Elton—new publisher, "Chemical Engineering" (N). . Feb. 22 *68

Chemical Industry
Capital cost estimates for process industries—report. J. W. Hackney (charts & table) Pt 1 Mar. 7 113, Pt 2 ..... Apr. 4 *119
Capital spending for '60-'61 will total $1.66 billion (N) ..... Apr. 4 76
Concentration areas of U. S. CPI plants (table) ..... Sept. 19 108
ECM bait lands U. S. chemical cash (chart & table) ..... Nov. 14 124
Estimate working capital needs. L. R. Bechtel (table) ..... Feb. 22 127
Europe—Missing good bets in Europe? Feb. 22 74
Mexico—chemical men look south of the border. F. B. Loretta. . . . Feb. 8 74
Mexico—Mexican chemicals thrive. F. Loretta ..... Feb. 22 76
Pacific northwest CPI diversifies, integrates ..... Sept. 19 108
Processes—summary of latest developments ..... Apr. 4 66
Profit shrinks with costs up, prices static ..... Aug. 8 72
R & D has grown into an industry necessity—abstract from Giusti dissertation (chart & tables) . . . . Apr. 4 78
60's challenge chemical engineers—report ..... Jan. 11 *89
Socony-Mobil forms Mobil Chemical Co., a subsidiary (N) ..... July 25 62
Use capital ratio. Lynn & Howland (charts & tables) ..... Feb. 8 131
Chlorine—Electrolysis recovers chlorine from waste (chart) (N) ..... July 25 *63

Cleaning
Cold-cleaning solvent reclaimable by distillation ..... June 13 *96
Glass-cloth filter bags clean hot gas (N) ..... Jan. 25 *53
Ion-exchange resin cleaner. . . . . Nov. 28 98
Plastics remover for plastics molding machines ..... May 2 *80
Coal—Chemicals from coal produced at Sasol plant, South Africa—flowsheet Apr. 18 *156

Coatings
Acid tanks get seamless coating—Paraline RD polyvinyl chloride plastic Nov. 28 *96
Aluminum coating furnace-bonded for more uniformity ..... Feb. 22 *80
Cementable Teflon ..... Nov. 28 96
Ceramic-coated metals ..... Oct. 3 130
Chromium—thick plate gives better corrosion resistance ..... Oct. 31 *140
Coating process protects metal parts during heat treatment (N) . . . July 25 62
Colloidal silica protects painted surfaces ..... Mar. 21 104
Epoxy resin shows up well as pipe coating ..... May 16 96
Glass flakes in resin make a strong, new coating (tables) ..... Sept. 5 *162
High-boiling solvents make better surface coatings ..... Oct. 17 110
Latex—new paper coating material May 2 78
Metallic coatings—new surfacing methods vie with old. J. R. Schley (chart & table) ..... Mar. 21 *184
Nickel-aluminum coatings on metal resist oxidation ..... Oct. 31 140
Pipe plastic coated at A. O. Smith plant ..... Nov. 28 *162
Plasma-spray coats steel (N) . . . Dec. 12 *88
Plastic coating for lab glassware protects experimenters ..... Apr. 18 *110
Plastic coating protects electronic parts ..... May 16 *98
Primer—inhibitive primer shields metal surfaces ..... June 13 *98
Tungsten coatings easier to apply Mar. 7 *78
Vinyl-coated nylon for air-supported structures ..... July 25 *78
Zinc coating shortcuts repair, foils water-tank rust ..... Sept. 19 112

Coke and Coke Products
Coker moved 325 miles in record lift (N) ..... Apr. 18 *100
Fluid coking costs down, profits up—flowsheet ..... May 16 *112
Combustion—Zimmermann process consumes sludge by flameless combustion (N) ..... Nov. 28 *80

Communication
Employee communication—what makes Henry talk? D. J. Petruzzi. . May 16 *147
How to write a good technical article May 2 127

Compressors
Axial compressor gets key steel making job (N) ..... May 2 60
Choosing drivers for centrifugal compressors. F. L. Gillett (table). Mar. 7 143

Computers
CE Cost File 41. Computers for cost estimating ..... Oct. 3 119
Crude distillation unit at Standard refinery under computer control (N) Oct. 31 48
Distillation tower calculations—computer offers better solution of multicomponent system. A. M. Peiser (tables) ..... July 11 *129
Information retrieval—what will it do for the chemical engineer? J. W. Perry ..... Dec. 26 88
Monsanto's Barton Plant raises NH_3 output in big computer test (N) Nov. 14 *110
Should computers control your process? C. R. Hall (charts). . . . . Mar. 21 *153
Small computer solves big process problems at Pritchard (N) . . . . . May 16 *78
Special-purpose speeds mix formula calculating for H. P. Hood & Sons (N) Nov. 28 *84
Standard Oil of N. J. computer systems pay in dollars and sense (N). . Aug. 8 62
Systems engineering. T. J. Williams
See under **Engineering**

Concrete
Cement outlook: grim but hopeful. F. C. Price (chart) ..... Oct. 31 *60
100-yr. concrete test passes halfway mark (N) ..... Oct. 17 94
Prestressed concrete pipe gains favor as storage tanks ..... July 11 *164
Condensation—Arctic-bound condenser needs antifreeze (N) ..... Feb. 8 *68

Construction
Air-supported structure—world's largest is made of Geon-coated nylon July 25 *78
Butyl rubber waterproofs skyscraper foundation ..... July 11 *86
CE Cost File see under **CE Cost File**
Contract for nuclear power plant agrees to penalties for late delivery (N) May 16 82
Cost statistics for the cost estimator. Gertz & Dennee ..... Oct. 31 *97
Costs—where estimators go wrong. T. J. Roche ..... Aug. 22 125
Diamond Alkali's new caustic-chlorine cell room cost only 14 days downtime (N) ..... May 30 *42
Hints for plant startup. J. E. Troyan Pt 1 Troubleshooting new processes Nov. 14 *223
How to house process development—tear-in-print through Standard of Indiana's newest R&D building. G. W. Schustek Jr. ..... Feb. 8 *127
Retraying bubble cap columns. James Tipton (charts & table) ..... July 25 *134
Small-company expansions involve compromise ..... Oct. 31 64
Tower-lining scheme cuts expansion downtime (N) ..... Oct. 3 *50
Contacting—H_2SO_4: old dog, new tricks. D. B. Burkhardt (tables) . . . . Dec. 26 99

Containers
Containers for chemicals—report. T. E. Dowling (tables) ..... Oct. 3 *85
Fiber-glass containers for rockets' gas Sept. 19 *114
Multiwall paper containers. T. E. Dowling (tables) Pt 1 May 16 *164, Pt 2 May 30 *116

Continuous Processing
Better use for control charts. E. S. Aldredge ..... Jan. 25 *95
Chemico continuous operation ups alum recovery, cuts labor (N) . . . . Nov. 14 116
Decolorizing of liquid wax improved by continuous operation (chart) (N) Mar. 21 90
Gypsum process streamlined as continuous operation replaces batch kettles (chart) ..... Dec. 26 41
Process variables by chart. Gordon Marine (P.N.) ..... Dec. 26 *108
Pulping—Hammermill Paper's unique upflow process outstrips design capacity (chart) (N) ..... Oct. 31 52
Rocket propellant—Aerojet sets up first continuous propellant line (chart) (N) ..... May 2 *61

Controls
Automatic switch keeps cooling-tower water from city water cross-tie. R. L. Smith (chart) (P.N.) ..... Apr. 18 196
Better use for control charts. E. S. Aldredge ..... Jan. 25 *95
Beware detonations ..... Jan. 11 *105
CE Cost File 22. Process control instrumentation. Vilbrandt & Dryden Jan. 11 124
Controls wrap up cellophane manufacture at Avisco's Marcus Hook, Pa., plant—flowsheet ..... Mar. 7 104
How statistics apply to chemical processes. T. L. Koehler ..... Dec. 12 142
Interface control using thermistors. Frederick Fahnoe (P.N.) (chart) Feb. 22 152
Moscow control conference—First Congress of International Federation of Automatic Control. Ernest Conine Sept. 19 *181
Moscow control conference—interview with David M. Boyd, Jr. ..... Sept. 19 *184
Should computers control your process? C. R. Hall (charts). . . . . Mar. 21 *153
Systems engineering. T. J. Williams
See under **Engineering**
Thermistor liquid level control works in difficult service. R. E. Hudrlik (P.N.) (chart) ..... May 16 160
Water flow controls time-delay relay. Sideman & Giladi (P.N.) ..... Aug. 8 *145
Weighing for process control. R. Y. Moss ..... Aug. 8 *147

Copper
Innovations in the copper industry (N) Oct. 17 94
Low-temperature applications of copper and its alloys. C. L. Bulow (tables) Sept. 19 *187
Refining—new layout streamlines copper refining at Kennecott—flowsheet Mar. 21 *134

Corrosion
Add plastics to corrosion foes—outlook for glass-reinforced plastic. . . Oct. 17 *104
Anodic protection: how good is it? (chart) ..... Sept. 19 218
Antifreeze, Telar, rustproofs entire cooling system ..... May 30 64
Bromine corrosion—moisture is the key. Lake & Gunkler ..... Oct. 31 *136
Chromium—thicker plate gives better corrosion resistance ..... Oct. 31 *140
Congress—first International Congress on Metallic Corrosion invites papers Apr. 18 218
Corrosion-control design. See under **Design**
Evaluating wear-resistant materials July 11 *162
Gamma rays and film spot corrosion while equipment is operating. . May 30 *122
Inhibitive primer shields metal surfaces June 13 *98
Iron corrosion caused by oxide blades Sept. 5 *166
Lead-bonded metals shield radioactive corrosives (table) ..... Nov. 14 *252
Metal-bonded graphite materials. . . . Nov. 28 164
Metavanadate: effective inhibitor Oct. 3 134
Pipe custom plastic coated. . . . . Nov. 28 *162
Polyethylene pipe, impervious to corrosive soils, noses out steel for gas line (table) ..... May 30 124
Refractory sheet developments—pace quickens (table) ..... Nov. 14 256
Salt-water cooling problems — some cures ..... Aug. 22 164
Sulfuric-resisting alloys corrosion data. Schillmoller & LaQue (chart & table) Apr. 4 170
Tankers: stainless to plastic gamut Jan. 25 *130
Titanium tubing makes good in hypochlorite plant ..... May 30 *126
Titanium-palladium alloy superiority confirmed by tests ..... Aug. 22 166
Zirconium—higher purity boosts resistance. W. E. Kuhn (chart & tables) Feb. 8 *154

Costs
Batch equipment at minimum cost. S. E. Ketner (chart & table). . Aug. 22 121
Budgeting maintenance costs. J. W. Clayton ..... Feb. 22 *156
Capital cost estimates for process industries — report. J. W. Hackney (charts & table) Pt 1 Mar. 7 113, Pt 2 Apr. 4 *119
Computer systems cut costs at Standard Oil of N. J. (N) ..... Aug. 8 62
Containers for chemicals—report. T. B. Dowling (tables) ..... Oct. 3 *85
Critical path saves time and money. R. C. Steinfeld (charts) ..... Nov. 28 *148
Estimate manufacturing costs. R. M. Berry (chart & tables) ..... June 27 *123
Estimating bucket elevator costs. H. E. Mills (charts & tables) ..... Nov. 28 *117
Inventory control—Chemstrand's scientific inventory control. Mayer & Taylor (chart) ..... June 27 *140
Maintenance—Scheduling maintenance keeps costs in line. H. L. Timmons Mar. 7 *160

NOTES—(D.N.) Design Notebook; *Illustrated; (N) News; (P.N.) Plant Notebook

Materials control program for small plants. A. J. Bohl....Apr. 18 *206
Measuring and controlling maintenance costs. R. I. Reul (chart & tables) Sept. 19 203
Pollution cost is growing—60's challenge report....Jan. 11 103
Rising costs demand engineer-managers —60's challenge report....Jan. 11 101
Rx for better steam economy; condensate return systems. R. J. Lundrigan (charts & table)....Oct. 3 121
Small-company growth keyed to compromise on projects....Oct. 31 64
Standards help thwart rising costs—60's challenge report....Jan. 11 102
Statistics for the cost estimator. Gertz & Dennee....Oct. 31 *97
Where estimators go wrong. T. J. Ro he Aug. 22 125

Cotton
Market—pro and con for chemical marketers (N)....Jan. 11 50

Cryogenics
Cryogenic insulation helps store volatile liquids....June 27 84
Cryogenic temperatures become usual—60's challenge report....Jan. 11 96
Cryogenics moves in on methane—flowsheet....Sept. 5 *98
Insulating fill called Perlox....Aug. 22 82
Liquid hydrogen process at Linde Co. uses cryogenic procedures—flowsheet Oct. 17 *164
Low-temperature metals: a roundup. G. H. Zenner (tables)....Oct. 31 *117
Pressure vessel design for high or cryogenic temperatures. R. R. Maccary (charts)....Nov. 28 131

Crystallization
Arc-image furnace grows high-purity single crystals (N)....Jan. 25 *58
Changes in tungsten crystal give ne insight into catalysis (N)....Oct. 3 *46
Magnesium oxide crystals possess electronic-grade qualities....Sept. 5 74
Metal crystals — arc-fusion proc ss grows large refractory crystals (N) July 25 *62
Salt—Recrystallizer process automates salt refining (chart) (N)....Oct. 31 *49
Silicon of high purity yields single-crystal forms....Sept. 19 *110
Zeolite crystals....Dec. 12 100

D

Design
Acetylene transmission system design—safety aspects (charts)....Sept. 5 *131
Air coolers—improving air-cooler design. Collins & Mathews (charts & table)....May 16 *137
Ammonia converter design cools catalyst bed, generates steam, too (chart) (N)....Aug. 22 60
DX Sunray Oil's solvent dewaxing plant design (N)....Nov. 14 *118
Batch equipment—size calculations minimize costs. S. E. Ketner (chart & table)....Aug. 22 121
Benzene pipeline design prevents freezing in severe winter weather (N) Feb. 8 *70
Beware detonations....Jan. 11 *105
Bleach process—continuous controlled system improves bleach uniformity (chart) (N)....June 27 *64
Brick-lined process equipment. Donald Thompson (charts & table)
Pt 1 How to select and design Feb. 22 *129
Pt 2 Designing details....Mar. 21 *161
Capital cost estimates for process industries—report. J. W. Hackney (charts & table) Pt 1 Mar. 7 113-130, Pt 2....Apr. 4 *119 134
Carbide's new epoxide plant gets extraordinary, in-depth safety design (charts) (N)....July 25 *68
CE Cost File see under **CE Cost File**
CE Refresher see under **CE Refresher**
Corrosion-control design (charts & tables)
1. Plant site, layout minimize corrosion. R. B. Mears....Jan. 11 *104
2. Proper design voids equipment corrosion. Aaron Wachter...Feb. 22 162
3a Often overlooked reactor design factors. J. E. Dawson....May 2 *150
3b Keys to corrosion-wise reactor design. J. E. Dawson....May 16 *170
4a Valve design: special for corrosives. E. G. Holmberg....June 13 *238
4b Valves for severe corrosive service. E. G. Holmberg....June 27 *146
5a How to extend storage-tank life. C. K. Aldrich....July 25 *148
5b Design tips reduce tank failures. C. K. Aldrich....Aug. 8 *154
6. Better design stretches exchanger life. F. L. Whitney, Jr....Oct. 17 *214
7a Guides to reducing agitator failures. N. H. Parker....Dec. 12 *190
7b Fabrication: key to mixer corrosion. N. H. Parker....Dec. 26 *112
Distillation towers—computer offers faster-converging solution of multi-component system. A. M. Peiser (tables)....July 11 *129
Drainage design can give plants flood protection. G. P. Fulton (charts & tables)....May 2 129
Filtration equipment—graphical method aids constant rate filtration scaleup. White & Hyman....June 13 *219
Flow of fluids process design—report. E. E. Ludwig (charts & tables) June 13 *161
H_2SO_4: old dog, new tricks. D. B. Burkhardt (tables)....Dec. 26 99
Heat exchangers—Air-cooled heat exchanger design. F. L. Rubin..Oct. 31 *91
Heat exchangers—find effective length of U-tubes. Whitley & Ludwig (chart & tables)....June 27 111
Heat exchangers—mechanical and economic features of principal designs. Drake & Carp (charts & table) Apr. 18 165
How statistics apply to chemical processes. T. L. Koehler....Dec. 12 142
Hybrid rocket propulsion systems. Hendel & Cavecche....May 30 *93
Injection system lets oxygen replace air in oxidizing hydrocarbons (chart) (N)....Oct. 17 *92
Ion exchange becomes powerful processing tool. Seamster & Wheaton (charts & tables)....Aug. 22 115
Jacketed vessels—new design. C. A. Feichtinger (chart & table)...Sept. 5 *127
Maintenance—Rate instrument design for low-cost maintenance. A. T. Sherman (charts)....Mar. 21 178
Mercury cell design regenerates pickle liquor acid, recovers iron (N) (chart) May 16 82
Nitrous oxide plant designed as mobile unit for Army (N)....June 13 *84
Pressure relief—How to design a pressure relief system. Joseph Conison (charts)....July 25 *109
Pressure vessel design for high or cryogenic temperatures. R. R. Maccary (charts)....Nov. 28 131
Pressure vessels—how to select the best size. R. R. Maccary (charts & table) Oct. 17 187
Reactors—designing reactors for operation. M. S. Bass....July 25 *125
Rocket engines—cone shape has advantages....July 25 66
Sewers—how to size conduits for storm sewers. C. A. Lee (chart & tables) Oct. 3 97
Steam—proper condensate return systems offer savings. R. J. Lundrigan (chart & table)....Oct. 3 121
Space travel—photosynthetic gas exchanger system to keep men in rockets alive. Humphrey & Deindoerfer (charts & tables)....Apr. 18 *183
Systems engineering. T. J. Williams See under **Engineering**
Tank blastoff caused by bad design Aug. 22 *160

Design Notebook
Air lift operates from syphon. A. A. Mayling....Aug 22 *152
Chart finds heat loss rate. J. F. Kuong July 25 *146
Chart finds volume or density of air. J. A. Seiner....Mar. 7 *158
Chart for compression and expansion temperatures. C. A. Kleppe. Sept. 19 213
Corrosive-acids heater. R. T. Gaudlitz....Sept. 19 *214
Electrochemical fluorinator uses porous carbon anode. D. R. Allen...Sept. 19 *216
Extending viscosity and other data with existing charts. H. F. Reinhold, Jr....Apr. 4 162
Falling-film evaporator. M. S. Tendulkar....Oct. 17 *208
Find flashback velocity at high pressure. J. B. Conway....May 2 140
Flowmeter depends on variable weight. Mathewson & Smith...May 2 *136
Fluorescent particles for tracing liquid flow. Merton Allen....June 27 136
Gas flow calibration correction. Sidney Gross....Aug. 22 *154
Graph shows plant economics. Ron Carstens....May 2 *138
Heated arm simplifies solids distillation problem. Farkas & Ziv...Mar. 7 *158
How to evaluate interactions. C. A. Zapata (charts)....Apr. 4 160
"Hypodermic still" provides source of vapor-liquid data. P. J. Horvath July 25 *142
Inflated sleeve seals tank gage rope. W. E. Robertson (chart)....May 30 111
Laboratory solvent extractor. A. A. Mayling....Jan. 11 *128
Leak-proof joint for high Vacuum work. V. N. Schrodt....Jan. 11 *128
Multiple-pitch screw equalizes discharge. M. S. Bass....Jan. 11 *126
Nomograph gives pump horsepower. Katell & Wellman....Dec. 12 176
Nomographs help find tank diameter. Leon Green....Feb. 8 143
Correction....Apr. 18 198
Pilot plant steam generator boasts control. M. S. Schwartz (chart) Apr. 4 158
Pressure-enthalpy plot for Dowtherm A. Frank Maslan....July 25 *146
Process design of a distillation reflux drum. Friedman & Murtha..Nov. 14 235
"Quickie" sightglass for pilot plant reactor. R. E. Leonard....June 27 *138
Roll feeder controls solids flow. S. A. Jones....Aug. 22 *150
Save time with gas-law nomograph. Loy & Palumbo....May 30 *112
Shell-side heat-transfer coefficient. T. J. Browder (chart)....Oct. 17 206
Short-cut to equilibrium plots. Ferdinand Rodriguez....Mar. 7 *156
Slide-rule solution for cubic equations. Jesse Roth....Jan. 11 130
Slurry feeder for pilot plants. Gordon MacBeth (chart)....Mar. 7 154
Some rules of thumb for quick estimations. J. Klengen....Mar. 7 156
Sum-of-years depreciation. J. F. Kuong Nov. 14 236
Test your CEQ. Robert Lemlich Oct. 17-207, Nov. 14-236, Dec. 12 178
Timed bench-sized screw feeder. C. A. Zapata....Feb. 8 *144
Twin orifices proportion liquid to gas flow. L. D. Brice....Jan. 11 *130
Use template to speed repetitive calculations. C. F. A. Roberts..June 27 *136
Vapor pressure of organics. W. Shulman....Dec. 12 180
Detergent—Fuel oil additive boosts engine performance....Aug. 8 78
Dialdehyde
Dialdehyde starch—new chemical via new electrolytic cell (N)....Feb. 22 *64
Price cuts develop new markets (N) Oct. 3 44
Dialysis—Breaks acid-recovery barrier at Phelps-Dodge (N) (table)....May 2 *64
Dichlorocarbene—new chemical via German synthesis (N)....Sept. 19 94
Dihydroxyacetone—available on commercial scale....Apr. 18 110
Dimethylsulfoxide—vies for status in fiber making (N) (chart)....Mar. 21 *86
Distillation
Azeotropic and extractive distillation—report. Jesse Coates....May 16 *121
Computer offers better solution of multi-component distillation tower system. A. M. Peiser....July 11 *129
Entrainment from perforated bubble trays at close spacings. L. Friend & others (charts & tables)....Oct. 31 101
Heated arm simplifies solids distillation problem. Farkas & Ziv (D.N.) Mar. 7 *158
Hydrogen distillation for heavy-water production on stream in France (N) Mar. 21 *92
"Hypodermic still" provides source of vapor-liquid data. P. J. Horvath (D.N.)....July 25 *142
Process design of a distillation reflux drum. Friedman & Murtha (D.N.) Nov. 14 235
Review principles of distillation—CE Refresher. Coates & Pressburg (charts)....Nov. 28 137
Sea water—giant still slated for Caribbean (N)....Mar. 21 94
Short-cut to equilibrium plots. Ferdinand Rodriguez (D.N.)....Mar. 7 *156
Drafting—CE Cost File 32. Estimating engineering drafting costs. D. F. Brosnan....May 30 114
Drugs
Enzyme, Cellase 1000, prevents intestinal distress....Oct. 31 72
Longevity increase brings a problem—60's challenge report....Jan. 11 90
Mepyrium prevents poultry disease July 25 80
Synthetic oral penicillin....May 2 *82
Drums
Containers for chemicals—report. T. E. Dowling (tables)....Oct. 3 *85
Process design of a distillation reflux drum. Friedman & Murtha (D.N.) Nov. 14 235
Drying
Activated alumina for gas drying. Dieter Janchen (charts)....Oct. 31 115
"Atomized suspension technique" (AST) replacing bacterial digestion for treatment of municipal sewage sludge in Quebec (N)....Jan. 25 *56
Paper drying speeded with new high-velocity air-shrouded dryers (table) (N)....June 13 *79
Rubber—extruder-dryer produces high-quality SBR rubber fast (N)..Aug. 8 *63
Spray drying process converts paste to powder (N)....Mar. 21 *83
Dust and Fume Handling
Chain scraper for dry dust collectors. A. J. Stewart (P.N.)....July 11 *154
Pollution control cost is growing—60's challenge report....Jan. 11 103
Smog—California fights auto-derived smog (N)....Feb. 22-68, Apr. 4 65 May 2 68
Temporary dust collector saves two months' time. T. M. Sheets (P.N.) Oct. 31 *122
Dyes—Dye-solvent carrier shortens dyeing cycles....Sept. 19 *112

E

Economics
Aluminum takes more of automotive market....Aug. 8 72

Australia adds petrochemicals to its chemical boom .....Oct. 3 *58
Better forecasts of instruments sales (tables) .....Mar. 7 72
Butyl rubber's new market pattern May 2 *70
Capital cost estimates for process industries—report. J. W. Hackney (charts & table).....Pt. 1 Mar. 7 113-130 Pt. 2 Apr. 4 *119-134
Carbon black masterbatch takes off. Frances Arne (charts).....Oct. 3 54
Cement outlook: grim but hopeful. F. C. Price (chart) .....Oct. 31 *60
The challenge of rising living standards—60's challenge report...Jan. 11 90
Chemical lubes measure up. Frances Arne .....Jan. 25 *62
Chemurgy now promises attractive profits. R. P. Windisch.....June 13 94
Consultants need proper priming Apr. 4 84
CPI spending plans for '60-'61 (N) Apr. 4 76
Dynamite outlook: no new demand ahead .....Oct. 31 66
Estimate working capital needs. L. R. Bechtel (table) .....Feb. 22 127
Europe—ECM bait lands U. S. chemical cash (chart & table).....Nov. 14 124
Europe—missing good bets in Europe? Feb. 22 74
Fats and oils—low price ups animal fats' share of fats and oils markets (chart & table).....Nov. 28 90
Fiber glass markets' rate of growth quickens .....Aug. 8 72
Germany—East German chemical investments up .....Aug. 8 72
Germany—plastics imports, exports increase .....Sept. 5 70
Graph shows plant economics. Ron Carstens (D.N.) .....May 2 *138
How will titanium fare in 1960? (N) Feb. 22 66
Industrial gases ride technology boom. J. B. Bacon (charts & table)...Jan. 11 *54
Isophthalic gains via phthalic shortage .....Oct. 17 108
Investment yardstick—discounted cash-flow method evaluates opportunities. H. E. Kroeger (tables).....May 16 143
Japan doubling capacity for key petrochemicals .....Dec. 26 40
Mexico adds foreign aid to petrochemical plans .....Dec. 26 46
Mexico—chemical men look south of the border. F. B. Loretta....Feb. 8 74
Mexico—Mexican chemicals thrive. F. Loretta .....Feb. 22 76
Monsanto stock option plan attracts 10,000 employees .....Sept. 5 146
Oil: the squeeze comes in the '60's. J. B. Bacon (tables).....Mar. 21 96
Oil-based aromatics gain first place. Messing & Bradley (tables)..Dec. 26 50
Pacific northwest CPI diversifies, integrates .....Sept. 19 108
Petrochemicals. Messing & Bradley.
1. An industry maps its mature years (chart) .....May 30 54
2. Chemicals from methane..June 27 74
3. Ethylene copes with growing competition (tables) .....Aug. 22 66
4. Propylene sires industry's new hopefuls (tables) .....Sept. 5 60
Plastics make a dent in paper markets. G. B. Hegeman (table).....May 16 88
Polycarbonate prospect: markets up, prices down .....Oct. 17 108
Process industries up research spending .....Oct. 31 66
"Productivity" means many things Feb. 22 72
Profit shrinks with rising costs, static prices .....Aug. 8 72
Pulp and paper: new problems. R. A. Labine (charts) .....Dec. 12 92
R & D becomes an industry necessity—abstract from G. P. Giusti dissertation (chart & tables).....Apr. 4 78
Reinforced-plastic corrosion-resistant equipment may take big leap..Oct. 17 *104
Resins' stake in easy-care cotton July 25 *74
Rubber — tree rubber's successors readied. Frances Arne.....Sept. 19 104
Sulfur supply and demand outlook to 1970 .....Aug. 8 72
U. S. ammonia feels foreign impact. J. A. King (chart & tables)..July 11 *82
Use capital ratio. Lynn & Howland (charts & tables).....Feb. 8 131
Westinghouse president sums up efforts to make basic research solvent May 2 74
Zinc oxide—markets shift in rubber, paint .....May 30 60

Education
Corrosion problems in the process industries—course at Ohio State Univ. July 11 166
Education faces up to '60's challenge—60's challenge report.....Jan. 11 99
New schools for chemical engineers Mar. 7 150
Ph. D. available in six-year course Sept. 5 146
Tax deductions for education expenses —IRS bulletin .....Sept. 5 146

Elastomers
Abrasion-resistant polyurethane July 25 78
Fluorinated synthetic has improved workability .....Apr. 18 112

Electricity
Anode material—titanium plated with platinum .....Jan. 11 60
Anodic protection: how good is it? (chart) .....Sept. 19 218
Cesium cell efficiently converts A-heat into electricity (N).....Oct. 3 50
Conduits of plastic vie with wood, ceramics .....May 2 *78
Electrochemical fluorination cell uses porous carbon anode. D. R. Allen (D.N.) .....Sept. 19 *216
Fuel cells—GE's new "solid electrolyte" fuel cell (N).....May 30 50
Interface control using thermistors. Frederick Fahnoe (P.N.) (chart) Feb. 22 153
New cell, new chemical—dialdehyde starch (N) .....Feb. 22 *64
Solar energy, fuel cells slated to be teamed (N) .....Feb. 8 62
Soviets develop portable, high-voltage atomic generator (N).....Apr. 18 92
Thermoelectric generator put on sale by British firm (N).....Feb. 8 62
Thermoelectrics, magnetohydrodynamics, thermionics—devices for future power needs (N).....Apr. 18 *88
Two-stage a.c. electric arc process boosts acetylene yields (N)...Nov. 14 120
Wire—from exploding wire, more thrust into space (N).....Feb. 22 64

Electrolysis
Chlorine recovered from waste with de Nora electrolyzer (N)....July 25 *63
Pressure lowers electrolytic H_2 cost (N) (chart) .....Mar. 7 *66

Emulsifiers
Alkyl phosphates stabilize polymerizations .....Nov. 14 136
Nonionic emulsifiers improve agricultural sprays .....Mar. 7 78

Enamel—Polyester wire enamel shows high heat resistance.....Mar. 21 104
Encapsulating machine for high-speed, mass production (N).....June 27 70

Engineering
CE Cost File 44 & 45: Engineering valuation. Haselbarth & Berk Nov. 14-244, Nov. 28-146
Chemical process systems engineering. T. C. Wherry (tables).....Dec. 12 *153
Conference on the New Chemical Engineering .....Sept. 19-*94, Oct. 3-48 Oct. 17-*91, 98, Oct. 31-*56, 142
Conference—Adm. W. F. Raborn—speaker (N) .....Oct. 17 *91
Conference on the New Chemical Engineering. S. D. Kirkpatrick..Dec. 12 141
Critical path saves time and money. R. C. Steinfeld (charts).....Nov. 28 *148
DX Sunray Oil's solvent dewaxing plant design (N) .....Nov. 14 *118
Engineering-unit prefixes named (N) Feb. 8 62
Estimate engineering properties. W. R. Gambill (charts & tables)
Calculate engineering properties Jan. 11 109
Evolutionary operations can optimize your chemical process. J. S. Hunter (charts & tables).....Sept. 19 193
Flow of fluids process design—report. E. E. Ludwig.....June 13 *161
Interpreting dimensionless groups. L. t.. Tao .....Nov. 28 129
Plant startups. J. E. Troyan
How to prepare for plant startups Sept. 5 *107
Part I Troubleshooting new processes Nov. 14 *223
Systems engineering. T. J. Williams (charts & tables) Pt. 1.....Feb. 8 *121
Pt. 2—Process research .....Mar. 7 *131
Pt. 3—Process development ..Apr. 4 *139
Pt. 4—Preliminary plant design May 2 *121
Pt. 5—Process plant design..May 30 *97
Pt. 6—Plant studies .....June 27 *113
Pt. 7—Process control .....July 25 *119
Pt. 8—Control theory .....Aug. 22 *127
Pt. 9—Control design .....Oct. 17 *181
Pt. 10—Systems literature ...Nov. 14 *227
Pt. 11—Systems literature ...Dec. 26 101

Engineers
Are we meeting the union challenge? E. A. Hartsook.....Feb. 22 145
Canada reports 1960 engineering salary data (tables) .....Dec. 12 168
Career centers—get your next job the new, easy way. R. F. Fremed Nov. 28 *154
Chemical engineer turned diplomat. Arthur Erikson .....May 30 *107
Chemical engineers find more room in maintenance .....Jan. 25 126
Chemical engineers—of 10,000 . . . you're the smartest.....Apr. 18 202
Chemical engineers prominent in maintenance .....May 30 120
Consider a job in technical service. Lange & Crom.....Aug. 22 142
Conference on the New Chemical Engineering. See under **Engineering**
Consultants need proper priming..Apr. 4 84
Cost engineers—statistics for the cost estimator. Geriz & Dennee...Oct. 31 *97
Cost engineers—where estimators go wrong. T. J. Roche.....Aug. 22 125
Do you have a permanent job? Really? A. W. Gray.....Sept. 5 *142
Does your employer own your knowledge?—follow-up report ....June 13 222
Employment pointers in two new booklets .....Sept. 5 146
Engineering or management careers?—ORC surveys engineers' attitudes July 25 127
How many are there?.....Mar. 7 150
How to start out on the right foot. R. G. Powell.....Sept. 19 *209
How to write a good technical article May 2 *127
Information problem—how to get through the sea of words. L. W. Ross .....Mar. 21 *143
Intellect is not mortgaged, court rules Mar. 7 150
The management function of the engineer in industry. H. S. Bunn Nov. 14 *239
NSPE's new policy on unions..May 2 128
Phillips Petroleum Co. wins NSPE award as best engineering employer June 27 *128
Politics—Engineers enter the political arena .....Jan. 25 *115
Politics—If your company gets into politics. Stewart Ramsey....Jan. 25 118
Profession profile—Florida's report on its engineers (charts).....Oct. 3 126
Profile of a team—Hercules Powder Co.'s propulsion proposal team. R. F. Fremed .....Oct. 17 *198
Read your government research contract carefully .....Oct. 31 66
Rising costs demand engineer-managers—60's challenge report..Jan. 11 101
Salaries—Chemical engineers: $125,232 per dozen (table).....June 13 221
Salaries—Demand forces salaries up again (chart & table).....Feb. 8 139
Salaries—Executives: total compensation of some top CPI executives (table) .....July 11 140
Salaries—A new yardstick for measuring your pay.....Jan. 11 *120
Salaries—Top pay, starting pay and your pay (chart & table)....July 11 140
Salaries way up for beginners..May 30 110
Salaries—What basis for comparing salaries? R. F. Fremed (chart) Oct. 3 125
Score your executive attributes. R. S. Schultz .....Oct. 31 131
Secretaries who talk your language Mar. 7 *148
60's challenge chemical engineers—report .....Jan. 11 *89
Space technology offers key role May 30 110
Speeches—Beware of the expert speech makers. W. A. Sylvester.....Aug. 8 143
Speeches—The next talk you have to give. Lawrence Murphy.....Apr. 4 *151
Strike at Britain's Atomic Energy Research Establishment .....Apr. 18 204
Strike—one-week strike wins benefits (N) .....Aug. 22 62
Tulsa panel probes professional conduct .....Dec. 12 170
What engineers should know about patents and claims. Floyd Trimble Oct. 3 113
You must deliver competency and skill. A. W. Gray.....Mar. 21 *169

Engines
Atomic rocket engine runs 15 minutes in successful test.....Dec. 26 40
Choosing drivers for centrifugal compressors. F. L. Gillett.....Mar. 7 143
Jet engine grounded to drive natural gas pipeline compressor....Dec. 26 *42
Rocket engines—cone shape has many advantages .....July 25 66
Entrainment—New data on entrainment from perforated trays at close spacings. L. Friend & others (charts & tables) .....Oct. 31 101

Equipment
Batch equipment at minimum cost. S. E. Ketner (chart & table)..Aug. 22 121
Brick-lined process equipment. Donald Thompson (charts & table)
Pt. 1—How to select and design Feb. 22 *129
Pt. 2—Designing details ....Mar. 21 *161
Capital cost estimates for process industries—report. J. W. Hackney Pt. 1, Mar. 7 113, Pt. 2.....Apr. 4 *119
CE Cost File 24: Construction equipment rental rates. C. A. Adams Feb. 8 146
Corrosion-control design
2. Proper design voids equipment corrosion. Aaron Wachter..Feb. 22 162
Costs—no slackening in upward cost trend—Marshall and Stevens annual indexes of comparative equipment costs 1913-1959 (charts & tables) Apr. 4 149
Costs, see also **"Chemical Engineering Cost File"**
Filter media—a new guide. J. P. Kovacs (table) .....June 13 *209

NOTES—(D.N.) Design Notebook; *Illustrated; (N) News; (P.N.) Plant Notebook

Heat exchangers—guide to shell-and-tube heat exchangers. Drake & Carp (charts & table)....Apr. 18 165
Leasing—more firms see gain in equipment leasing (N)....Feb. 22 60
Liquid hydrogen equipment gets evaluation tests (N)....Oct. 17 *94
Packaging machines for measuring and filling—Containers for chemicals. T. E. Dowling....Oct. 3 *94
Pressure vessels—how to select size. R. R. Maccary....Oct. 17 187
Purchasing process equipment. N. H. Parker
How do you evaluate the proposal? Pt. III....Jan. 25 111
Russians lack chemical equipment, turn to West (N)....Jan. 11 44
Sum-of-years depreciation. J. F. Kuong. (D.N.)....Nov. 14 236

Equipment News

Actuator, linear....Apr. 4 *191
Actuator, valve....Feb. 22 84
Air compressor....Nov. 14 *142
Air filter, cubic....Mar. 21 *204
Air tester, portable....July 11 96
Alarm rotameter....Sept. 5 *184
Analyzer, beryllium....Mar. 7 *86
Analyzer, continuous....June 13 259
Analyzer, moisture..Oct. 3 *144, Dec. 26 70
Analyzer, oxygen....Mar. 21 108
Analyzer—photoelectric comparator....July 11 *96
Analyzer, photometric....Oct. 3 144
Analyzer, waste-water....Apr. 18 *236
Automatic system handles batch or continuous blending....Oct. 3 *66
Bags, heat sealed multiwall....June 13 261
Balance—thermo-balance....Sept. 19 *120
Batch controller....Apr. 4 *192
Batching system....Apr. 4 *188
Blender-hopper....May 2 *84
Blender, ribbon....Feb. 22 86
Blender, world's biggest....Feb. 8 *84
Blower unit—package....July 11 *182
Blowers, vacuum....Jan. 11 *68
Boiler, packaged....Dec. 12 *215
Breather, rescue....May 2 *84
Bridge breaker....Dec. 12 *218
Calibrator, pressure....May 16 100
Calibrator, pyrometer....Feb. 8 *86
Centrifuge....May 2 *86
Centrifuge developments....Feb. 8 84
Centrifuge—new models round out centrifugal line....Jan. 25 *74
Chart integrator....Oct. 17 *243
Chromatograph is faster....May 16 *192
Chromatograph, process....Jan. 25 147
Chromatographs get programmed controls....Aug. 22 *84
Circuit breaker....June 27 88
Circuit checker....May 16 *102
Clamp, support-rod....Nov. 28 *176
Classifier, air, separates solids sharply....Sept. 5 *78
Cleaner, hydraulic jet....Oct. 31 78
Clothing, asbestos....July 11 180
Compressor, centrifugal....Jan. 11 *170
Computer, digital....Mar. 21 *112
Computer—a step closer to automatic control....Sept. 19 *116
Condenser, vapor....Sept. 19 249
Connection head....Apr. 4 *191
Connectors, flexible....Feb. 22 *88
Containers — collapsible containers for bulk shipments....Oct. 17 *116
Control, liquid-level....Oct. 17 *244
Control, pressure....Mar. 7 182
Controller, multipoint....Sept. 5 *182
Controller, pump....Sept. 19 *120
Controllers, vacuum Aug. 22 *90, Oct. 31 *76
Conversion unit....Mar. 7 *184
Converter, signal....Nov. 28 104
Conveyor belt....Feb. 8 *173
Conveyor—high-speed hurling device....Apr 4 94
Cooler, drum-type....Oct. 31 158
Coupling, flexible....Dec. 26 *68
Coupling, hose....Oct. 17 *242
Coupling, shaft....Oct. 17 118
Couplings, flexible Sept. 5 *186, Dec. 12 *106
Crusher, for slurries....Mar. 7 *86
Crushers, single-roll Mar. 21 *202, Oct. 17 *247
Cutter, tube-bundle....Jan. 11 *68
Damper, shutoff....May 2 169
Damper, vibration—built in....Mar. 21 *108
Data logger-annunciator continuously records 400 variables....Nov. 28 *102
Densimeter....Oct. 17 120
Densiometer....Apr. 18 238
Detector, bubble....May 16 *102
Detector, gas....Apr. 4 *192
Detectors, signal....June 13 *260
Dewpoint instrument....Nov. 14 *279
Disintegrator....Feb. 22 *84
Distillation column using rotary trays cuts pressure drop....Aug. 8 *82
Drive, fluid-mixer....Jan. 25 *149
Drive, multi-speed....Apr. 4 *190
Drives, adjustable....Feb. 8 *172
Drives, variable-speed....May 16 *200
Drum carrier....Sept. 5 *80
Drum, paperboard....Dec. 12 106
Drum heater, portable....July 11 *184
Drum opener, automatic....May 30 *135
Dryer, air and gas....Sept. 19 *238
Dryer—bench-scale rotary dryer....June 27 *88
Dryer for gases....May 2 *86
Dryers, air Jan. 11*168, Feb. 22 *88, July 11 *181
Dust collectors....Jan. 11 *66, Feb. 8 *170
Ear plug....June 13 262
Electric tracksetter....Dec. 12 108
Electricity—portable A.C. power....June 13 104
Engine control system....July 25 169
Engine, gas turbine, delivers 900 Hp....Apr. 4 *94
Evaporator stripper....Dec. 26 *125
Extractor—basket extractor keeps beds stationary....July 25 *84
Extractor, solvent....Aug. 22 90
Fan, all-vinyl....Sept. 19 *246
Fan, centrifugal....Oct. 17 *245
Fans, industrial...Jan. 11 *66, Mar. 21 205
Fastener, Velcro's nylon tape...June 13 *106
Faucet, drum—plastic....June 27 *172
Feeder, constant-head....May 30 *72
Feeder, solids....Sept. 19 *249
Filler, piston....Mar. 21 *110
Filter cartridge....Oct. 17 *246
Filter, duplex....Mar. 21 *203
Filter, fiber-glass....May 30 74
Filter holders....Apr. 18 *121
Filter, micron-size....June 27 172
Filter, porous metal....June 13 106
Filter, pressure....Jan. 25 *78
Filter, small, with backwash feature....June 13 *258
Filter, straight line....May 30 *74
Filters, air....Oct. 31 *161, Nov. 14 *278
Fire-detection tube....Nov. 14 144
Fire extinguisher....June 27 *166
Fittings, aluminum....Feb. 22 *181
Fittings, saw cross....Jan. 11 *70
Fittings, thermoplastic....Jan. 11 *70
Flaring tool....Aug. 22 *90
Flow element....May 16 *194
Flowmeter, air....May 16 *104
Flowmeter, miniature....Aug. 8 *173
Flowmeters, solids....Sept. 19 *242
Flowmeter, ultrasonic....Apr. 18 *242
Flowmeter with bellows movement....Mar. 7 186
Gage accessories....Nov. 14 *281
Gage, moisture....July 11 *92
Gage, nuclear....Oct. 31 *159
Gage, precision, tank....Oct. 3 68
Gage, pressure, test....Dec. 26, *68
Gage protector....Nov. 28 *106
Gage, thickness....Oct. 17 246
Gage, vacuum ....Sept. 19 *239, Dec. 26 70
Gage connection, rotating....Mar. 21 *208
Gages, density....Jan. 11 *70
Gages, pressure....Apr. 4 94
Gas detector....Oct. 3 *147
Gas indicator....Aug. 22 *181
Gas monitor....Apr. 18 *118
Gasket material..Apr. 18 240, Sept. 19 239
Gaskets, pipe....Apr. 18 *238
Gasoline for truck....Dec. 26 68
Gear reducer....Aug. 22 *88
Glove-heavy-duty....June 27 *168
Gravity system....Dec. 12 106
Grinding mill....Jan. 25 78
Heat exchanger....Aug. 8 *86
Heat transfer system....May 16 *200
Heater, air-gas....June 27 *90
Heater, band....Mar. 21 *112
Heater—electric drum-heater..Sept. 19 *244
Heater, pipe-joint....Dec. 12 *108
Heater, radiant gas....May 30, *136
Heater, space....Oct. 3 *146
Heater, tantalum....Apr. 18 *116
Heater, water....Aug. 8 *86
Hose and rings, Teflon....May 16 *102
Hose, flexible, for harsh steam service....May 16 *104
Hose, steel-armored nylon....Aug. 8 *84
Hydrogen plant....Nov. 14 282
Ignitor, gas-electric....June 27 *92
Impact tools....Dec. 26 124
Indicator, ribbon....Apr. 4 *98
Insulating sleeve....Oct. 17 *120
Insulation, electrical....Jan. 11 66
Insulation for fittings....Apr. 18 *118
Insulation spray-on unit....Aug. 22 88
Insulation, Thermo-lag....Feb. 22 84
Insulation—titanite in new forms....Apr. 4 *98
Joint, rotating....Apr. 4 100
Joints, expansion....Mar. 7 *86
Lamps, indicator....May 16 194
Level controllers....Oct. 17 118
Manway assembly....Jan. 25 78
Mask—air escape mask....May 16 *104
Metal detector....Oct. 31 *76
Metal sorter....Mar. 7 *179
Meter, automatic....June 13 *106
Meter, gas....Mar. 21 *202
Meter, recording pH....June 27 *92
Microfilmer....May 2 84
Mills, fluid energy....Feb. 8 86
Mixer, portable....Sept. 5 *180
Mixer, turbine....July 11 *94
Mixer with double-muller alignment....July 25 *86
Mixing machine....Jan. 25 150
Monitor, aerosol....Mar. 7 *86
Monitor, air-density....Oct. 3 *68
Monitor, moisture....Aug. 22 183
Monitor, radiation....July 11 *182
Monitor, solid-state....July 11 *94
Monitor, temperature....Feb. 8 *88
Monitor, viscosity....Oct. 3 *68
Motor and generator....Oct. 31 *76
Motor control centers....Mar. 7 180
Motor, weatherproof....June 27 *174
Motors for wide voltage range..Mar. 21 *110
Motors, induction....Mar. 7 *180
9% -nickel-steel alloy....Dec. 12 *104
Nut remover....Dec. 12 *213
Oscilloscope with digital readout....Mar. 21 *110
Oven, industrial....June 27 *169
Ovens, infrared....Feb. 22 *88
Overseas developments....Jan. 11 70
Oxygen mask system....June 27 *170
Oxygen source....Apr. 18 *121
Packing, formable....Sept. 5 181
Packing, tower....Apr. 4 *189
Pallet, magnesium....Jan. 11 *70
Pellet mill....May 2 *86
Photometer, flame....Oct. 3 *146
Pilot plant—package....Aug. 8 *170
Pipe, aluminum, with integral tracing....June 13 *106
Pipe connector....Apr. 18 *121
Pipe, furane plastic....Aug. 8 84
Pipe—"instant" concrete pipe..Mar. 7 84
Piston rings....Apr. 18 *118
Pistons, pump....May 2 *167
Plasma spray gun....Jan. 25 *148
Plates, heat-transfer....Oct. 17 *118
Pneumatic carrier....Feb. 8 *84
Polypropylene block....Mar. 21 203
Pressure regulator....July 11 *186
Pulse eliminator....Oct. 17 *120
Pump, air....Apr. 18 *237
Pump, all-glass....July 11 *92
Pump, centrifugal....Nov. 28 *106
Pump, chemical....Feb. 8 *86
Pump, cryogenic....Dec. 12 *108
Pump, general purpose....June 27 *92
Pump, high pressure....Oct. 31 *158
Pump, high-vacuum....Aug. 22 *187
Pump, leakproof....Feb. 22 *181
Pump, multi-capacity....July 11 *94
Pump, plastic gear....Nov. 28 106
Pump, reciprocating....Feb. 8 173
Pump, rotary....Feb. 8 *86
Pump, sealless....July 25 *88
Pump, sealless sump....June 13 *104
Pump, sealless, water....Oct. 3 *68
Pump, self-priming....Nov. 14 *142, Dec. 26 *124
Pump, steam-jacketed....Oct. 3 *146
Pump, subminiature....May 16 *104
Pump, transfer....Feb. 22 *187
Pump, vacuum....July 25 165
Pump, vertical....Dec. 12 *108
Pumps, canned....May 2 *84, July 11 *92
Pumps, centrifugal....Jan. 25 *146, May 16, *193
Pumps, gear....July 25 *169, Nov. 14 *282
Pumps, metering...Feb. 8 *88, Apr. 18 116
Pumps, plunger....Jan. 25 *148
Pumps, vane....Feb. 8 *88, Dec. 12 *221
Radiometer, industrial....Jan. 25 *147
Reactor, three-stage....Aug. 8 *172
Readout....Jan. 25 *78
Receiver, remote....May 2 *167
Recorder, combination....Aug. 22 *183
Recorder, dewpoint....Sept. 5 80
Recorder, digital....Apr. 4 190
Recorder, multipoint....Apr. 18 *241
Recorder, peak....May 30 72
Recorder, X-Y....Oct. 3 *70
Recorders, strip-chart....Mar. 7 *178, Oct. 17 *120
Refractometer....Sept. 19 *240
Regulator, gas....Oct. 3 70
Regulator, instrument....Apr. 18 *121
Regulator, metering....Nov. 14 *279
Regulator, process....Nov. 14 *277
Regulator, solenoid....Jan. 11 *167
Regulators, pressure....Apr. 4, 193, Aug. 8 *86, 171
Repair kit....Jan. 11 167
Rotameters, transmitting..Feb. 8 *88, Nov. 28 *178
Rupture disk....Aug. 22 *90
Safety shower....Dec. 26 *70
Sampler, effluent....Feb. 22 *188
Scales, bench....July 25 *88
Screen, portable....Oct. 17 249
Screen, vibrating....Oct. 17 *250
Screen, wedge-wire....May 2 *86
Screener, sanitary....Nov. 14 *274
Screen-feeder....Aug. 8 *173
Screens, Cirlyptic....June 13 *102
Screens—pierced metal sheet..Mar. 21 *206
Screens with loose-rod decks resist blinding....May 16 *100
Scrubber adjusts for variable flows....May 30 *70
Scrubber, air....Dec. 26 *126
Seal, flared tubing....July 11 *180
Seal, waste-pipe....May 30 *135
Separator, entrainment....Feb. 22 *182
Separator, multistage....Jan. 25 *74
Separators, centrifugal....Jan. 11 *166
Sewage plant, compact....Nov. 14 *144
Shakeout, railroad car....Apr. 18 118
Sheet, perforated....Apr. 18 246
Shield, face....Aug. 22 *90
Ship—new bulk cargo vessel docks anywhere....Sept. 19 *118
Shunter, railcar....June 13 *104
Sifter for harsh service....Mar. 21 *110
Slide rule, pocket, circular....Aug. 22 *88
Solids processor....Apr. 18 *240
Sorptometer....Jan. 11 *66
Speed reducers....Sept. 5 *82, Oct. 17 *120
Spray gun....Apr. 4 *100
Spray gun applies epoxy coatings....May 30 74
Starter....Apr. 18 *244
Steam trap, valved....June 27 *92
Steel—pt-clad stainless steel....Jan. 11 168
Steel, strong alloy....June 13 102
Strainer, polypropylene pipeline....Nov. 28 *106

NOTES—(D.N.) Design Notebook; *Illustrated; (N) News; (P.N.) Plant Notebook

Strainer, self-cleaning .....Feb. 8 *171
Strapper, automatic .....Aug. 8 *86
Strapping, rayon cord.....June 13 104
Suit, disposable safety.....Feb. 22 *88
Suit, fire rescue.....Oct. 17 *250
Suits, safety .....May 16 *198
Suppressor system nips explosions Nov. 14 *140
Sweeper, power .....Oct. 31 161
Switch, canned .....May 16 *197
Switch, flow .....Aug. 22 88
Switch, level, for small hoppers July 11 *94
Switch, miniature air .....Nov. 28 176
Tachometer, hand .....Dec. 12 *217
Tank, collapsible outdoor.....Feb. 22 *84
Tank—foldaway tank for trucks.Dec. 26 68
Tank, insulated .....Apr. 4 94
Tank, storage .....Dec. 26 *68
Tank car, giant could carry 30,000 gal. of mustard .....Nov. 28 *104
Tanks, rubber, store oil underwater Oct. 3 *70
Tape, pipe, prevents corrosion..Mar. 21 112
Temperature controllers..Mar. 21 108, June 27 *169
Temperature cutout .....Oct. 3 *145
Temperature probe .....June 27 *166
Temperature sensor .....Feb. 22 *180
Thermocouple gland .....Apr. 4 *194
Thermocouple, high - temperature — tungsten .....July 11 92
Thermocouple, small .....June 13 106
Thermometer, electronic .....May 2 *166
Thermometer on 6-ft. stem.....May 30 *74
Thermometer, surface .....Aug. 8 *169
Thermoplastic recording (TPR)—new route to ready information...Mar. 7 *82
Thread-sealer, dry .....Sept. 5 182
Timer, pneumatic .....Jan. 11 *68
Trailer, compaction .....Feb. 8 *171
Transducer, tiny .....Sept. 19 *120
Translators of silicon carbide...Dec. 12 *106
Translator, A/D .....Feb. 22 *86
Transmitter, data .....Sept. 5 80
Transmitter, pneumatic, for process variables .....May 16 100
Transmitter, program .....Mar. 21 *205
Traps, magnetic bowl.....Jan. 11 *165
Treater, chemical .....Apr. 4 98
Truck, electric .....Dec. 26 *124
Tube, pitot .....Aug. 22 *183
Tubing harness .....Sept. 5 82
Turbine, gas .....Apr. 18 *236
Turbine, steam .....Oct. 17 *249
TV monitor for boiler fire.....June 27 *90
Ultrasonic device finds weak spots with plant on stream.....Oct. 31 *74
Valve, actuated ball .....Nov. 14 *277
Valve, ball—flanged .....Oct. 31 *76
Valve, ball—plastic .....June 27 90
Valve, bulk-solids .....Mar. 7 *178
Valve, check—ball .....Aug. 22 *185
Valve, check—hinged .....July 11 *92
Valve, control .....May 2 *168
Valve, controlled-flow .....Sept. 19 *120
Valve, convertible .....July 11 *186
Valve, diaphragm .....July 25 *166
Valve, discharge .....Mar. 7 *186
Valve, extended-bonnet .....Oct. 31 *162
Valve, flexible-sleeve .....Nov. 14 *280
Valve, floating-cone .....Sept. 19 238
Valve, foot .....Jan. 25 *150
Valve, 4-way control .....Aug. 22 *185
Valve, globe angle .....Nov. 28 *104
Valve, globe—PVC .....July 25 *88
Valve, laboratory .....Apr. 4 *98
Valve, miniature .....Oct. 3 *149
Valve, needle, with plastic tip..June 13 *261
Valve operators...Feb. 22 *86, Mar. 21 *112
Valve, pipeline .....May 2 *169
Valve, porcelain .....July 25 *88
Valve positioner .....July 25 *164
Valve, reducing .....Jan. 25 *78
Valve, relief .....Dec. 12 *215
Valve, safety relief .....Jan. 11 *68
Valve, tank car seal.....June 13, *262
Valve, throttling .....Feb. 22 *86
Valve, Venturi-type .....June 13 *259
Valves, ball .....Apr. 18 *246
Valves—giant ball-valves master huge LOX, propellant flows.....Oct. 31 *78
Valves, gate..Feb. 22 *189, Mar. 7 *187, Oct. 31 *78
Valves, high-pressure....Apr. 4 *100, July 11, *96, Sept. 5 *186, Nov. 14 *144
Valves, manifold..Mar. 7, *182, Aug. 8 *171
Valves, sampling..Apr. 4 *100, Apr. 18 *118
Valves, solenoid..May 30 *135, July 25 *165, Oct. 31 *161
Valves, two-way .....May 2 84
Ventilators, portable .....Aug. 8 *169
Vibration absorber .....Apr. 4 189
Vibrator, bunker .....Aug. 22 181
Vibrator, electric .....Oct. 17 243
Vibrator, explosion-proof .....Apr. 4 *98
Vibrator, pneumatic .....Oct. 3 *70
Videograph .....Apr. 4 100
Water chiller .....Sept. 19 244
Water treatment plant.....Nov. 14 142
Weigher, continuous .....Sept. 5 *181
Weighing system .....Jan. 11 66
Welding machine, vertical.....Feb. 22 *187
Wire, TC extension.....June 27 *166
"Wood hog" chews up rubber for research .....Sept. 5 *82
Espionage, Industrial—The truth about industrial spying. R. A. Labine Feb. 22 *121

Ethylene
Czech electric-arc process claims highest yield (N).....Mar. 7 62
Ethylene copes with growing competition — demand, supply, capacity, end-uses—Petrochemicals Pt 3. Messing & Bradley (tables).....Aug. 22 66

Evaporation
Another step taken to cut water evaporation (N) .....Mar. 7 68
Falling-film evaporator. M. S. Tendulkar (D.N.) .....Oct. 17 *208
How to calculate heat, water losses in metallurgical processing. B. L. Thomas (charts) .....Aug. 8 *129
Microballoons cut evaporation loss (N) Dec. 12 88
Review heat transfer principles—CF Refresher. Coates & Pressburg How heat transfer occurs in evaporations .....Feb. 22 *139
Multiple-effect evaporators ..Mar. 21 157
"Vac" evaporator cuts cost of sulfuric acid recovery (N).....Aug. 8 *66
Water evaporation studied (N)..June 13 88

Explosives
Dynamite—diminishing demand closes Atlas plant .....Oct. 31 66
Primer offers greater safety at less cost Aug. 8 *78

Extraction
Laboratory solvent extractor. A. A. Mayling (D.N.) .....Jan. 11 *128
Solvent extraction tackles separations of cobalt-nickel and rare earths (N) Apr. 4 66
Tar—new dual-solvent extraction process piloted at Texas plant (chart) (N) .....Apr. 4 *70

F

Feeders
Constant rate lab feeder. C. F. A. Roberts (P.N.) .....Dec. 26 107
Roll feeder controls solids flow. S. A. Jones (D.N.) .....Aug. 22 *150
Slurry feeder for pilot plants. Gordon MacBeth (D.N.) (chart).....Mar. 7 154
Timed bench-sized screw feeder. C. A. Zapata (D.N.) .....Feb. 8 *144

Fermentation
Dihydroxyacetone (DHA) produced from glycerine on commercial scale Apr. 18 110
Flask-tank setup for new microbial insecticide (chart) (N).....Oct. 3 *42
Submerged fermentation produces low-cost acetic acid in Taiwan (chart) (N) .....Sept. 5 50

Fertilizers
Ammonia——U. S. ammonia feels foreign impact. J. A. King (chart & tables) .....July 11 *82
Inventory of new plants and facilities Apr. 18 172
Inventory—semiannual inventory of new plants and facilities.....Oct. 17 173
Pelletizing gets two new approaches at Calspray plant—flowsheet ..Aug. 22 *106

Fibers
Cellulosic reclassification bid fails (N) Apr. 18 92
Dimethylsulfoxide vies for status among fiber makers (N) (chart)....Mar. 21 *86
Inventory of new plants and facilities Apr. 18 181
Inventory of new processes and technology .....May 2 115
Inventory—semiannual inventory of new plants and facilities....Oct. 17 178
Nonwovens, using paper technology, look to major textile markets.Apr. 18 *104
Teflon-fluorocarbon monofilament fiber Dec. 26 62

Filtration
A-bomb fallout—filter plant removes fallout in river (N).....Mar. 7 *60
CE Cost File 36. Plate-and-frame filters. J. L. Hutton.....July 25 132
Glass-cloth filter bags clean hot gas (N) .....Jan. 25 *53
Filter media—a new guide. J. P. Kovacs (table) .....June 13 *209
Graphical method aids constant rate filtration scaleup. White & Hyman June 13 *219
Repair filter weaves by fabric "welding". R. W. Moore (P.N.)....Aug. 8 146
Screens improve filter performance. Boyer & Avery (tables)....June 13 *226

Finance
Capital cost estimates for process industries—report. J. W. Hackney Pt 1 Mar. 7 113, Pt. 2.....Apr. 4 *119
Estimate working capital needs. L. R. Bechtel (table) .....Feb. 22 127
Investment yardstick—discounted cash-flow method evaluates opportunities. H. E. Kroeger (tables).....May 16 143

Flowsheets
Acetylene — high-pressure acetylene chemicals at GAF's Calvert City, Ky., plant .....Feb. 22 112
Alkylation unit yields dual benefit Dec. 12 *132
Alumina—Kaiser Aluminum & Chemical—new ideas refresh aluminum process. Chopey & Arnold Jr..Nov. 28 *108
Beryllium—pure beryllium via the fluoride process at Brush Beryllium Oct. 31 82
Cellophane—Controls wrap up cellophane manufacture at Avisco's Marcus Hook, Pa., plant.....Mar. 7 104
Coal chemicals—Taking a new look at coal chemicals .....Apr. 18 *156
Converting waste sludge acid to H_2SO_4 at Dixon Chemical.....Jan. 11 *80
Copper—New layout streamlines copper refining at Kennecott.....Mar. 21 *134
Cryogenics moves in on methane Sept. 5 *98
Fluid coking: costs down, profits up May 16 *112
H-iron process—making iron in a fluidized bed .....Feb. 8 *96
Hardboard plant boasts modern look Dec. 26 74
Helium—New plant counters helium shortage .....July 25 *96
Liquid hydrogen—How the Air Force liquefies hydrogen .....Jan. 25 *86
Liquid hydrogen—Industry joins liquid-hydrogen scene .....Oct. 17 *164
Making fresh water from salt water by two refrigeration routes.....June 13 *152
Pelletizing fertilizer—Two fresh approaches to pelletizing.....Aug. 22 *106
Polybutene process ready for export Aug. 8 *98
Polycarbonates: GE's polycarbonate resins plant .....Nov. 14 *174
Polyethylene—Linear polyethylene via the Phillips process.....Apr. 4 *110
Polypropylene by the Ziegler process at Humble's Baytown, Tex., refinery June 27 *96
Propylene—Pure propylene feeds new resin industry .....May 30 *78
Rubber—Flexible process makes silicone rubber at GE.....July 11 *102
Sugar refinery—Melt house redesigned for automatic flow.....May 2 *94
Sweet-gas process makes U. S. debut Sept. 19 *166
Trickle process cleans up distillates Oct. 3 76

Fluids
Ether—bis (m-phenoxyphenol) ether—may head roster of 1,000-F. space fluids. Charles Spar.....May 2 *77
Flow of fluids process design-report. E. L. Ludwig (charts & tables) June 13 *161
Interpreting dimensionless groups. L. C. Tao .....Nov. 28 129
Superfluidity: key to plating, welding routes? (N) .....Jan. 25 52

Fluorine
New sources of fluorine (N) (chart) Dec. 12 79
Radiation processing for compounds (N) .....Jan. 25 52

Foams
Dyna-Foam, expanded polystyrene, threatens paper .....Oct. 3 *62
Foam-dome shelters for the military Feb. 8 *78
Foam-separation process for atomic waste disposal (N).....Aug. 8 68
Foamed ceramic .....May 2 *80
Polyurethane foam for insulation Nov. 28 98
Silicone-glycol aids cell structure of plastic foam .....Mar. 7 *80
Urethane foam—chemical sieve material controls molding of rigid foams June 27 86
Urethane foam makes boats unsinkable .....Nov. 14 *134

Fuel
Additives, Paradyne HO-10 and HO-20, lower pour point of heating oils Nov. 14 134
Atomic fuel processing
Pt 2—Hanford: atoms for peace (chart) .....Jan. 11 *113
Pt 3—Idaho Falls: atoms in the desert .....Jan. 25 *105
Pt 4—Savannah River does it cheaper Feb. 22 *135
Pt 5—Oak Ridge: home of the bomb makes fuel for nuclear ship (chart) .....Mar. 7 *137
Binders for solid rocket fuels Sept. 5 51, 76
Boron-fuel status changed (N)..Jan. 11 44
Diborane—Callery's new process turns out small batches (N).....Apr. 4 68
Fossil fuels still carry the load—60's challenge report .....Jan. 11 93
Fuel-cell developments maintain fast pace (N) .....Oct. 31 54
Fuel cell—GE cell's acidic ion exchange membrane acts as electrolyte (N) May 30 50
Fuel oil additive boosts engine performance .....Aug. 8 78
Nuclear fuel advances may aid A-power economics (N).....Aug. 22 56
Prospects for nuclear process heat. Wright & Smith (charts & tables) Nov. 28 *123
Refrigeration boosts recovery of LPG from French Lacq areas gas (chart) (N) .....Sept. 19 96
Underground fueling system for jet aircraft uses largest aluminum pipe Nov. 28 *164

NOTES—(D.N.) Design Notebook; *Illustrated; (N) News; (P.N.) Plant Notebook

Furnaces
Arc-image furnace grows high-purity single crystals (N) ..... Jan. 25 *58
Combustion furnace is heart of process for converting waste sludge acid to H_2SO_4 at Dixon Chemical—flowsheet ..... Jan. 11 *80
Oxygen keeps steel in turmoil—latest area of attack—the blast furnace (N) ..... Nov. 28 *77
Rotating-furnace technique utilizes finer powdered carbide feed, improves nitrogenation (N) ..... Feb. 8 *66

G

Gages—Better way to read emergency delta P's. W. L. Scheirman..June 13 236
Gas
Absorbents—New absorbents cut H_2S removal cost (chart) ..... Dec. 26 44
Analyze absorption in gas separations—CE Refresher. Coates & Pressburg (charts) ..... Oct. 3 99
Calibration correction for gas flow. Sidney Gross (D. N.) ..... Aug. 22 *154
Drying—activated alumina for gas drying. Dieter Janchen (charts)..Oct. 31 115
Find flashback velocity at high pressure. J. B. Conway (D. N.)...May 2 *140
Fluor flowsheet uses new solvent to lower gas-treating cost (chart) (N) ..... May 30 *46
Gas-law nomograph saves time. Loy & Palumbo (D. N.) ..... May 30 *112
Glass-cloth filter bags clean hot gas (N) ..... Jan. 25 *53
Industrial gases ride technology boom. J. B. Bacon (charts & table)..Jan. 11 *54
Nitrogen oxide in inert gases cut by steam. T. W. Miller (P. N.)..June 13 *234
Refrigeration boosts LPG recovery from gas in Lacq area, France (chart) (N) ..... Sept. 19 96
Shock-tube research of high-temperature gas-phase reactions. Victor Kevorkian (charts) ..... Oct. 3 107
Generators
Cryogenerator produces hydrogen from ammonia right in the plant (chart) (N) ..... Aug. 22 *54
Future power generators—exotic devices use thermoelectrics, magnetohydrodynamics, thermionics (N) ..... Apr. 18 *88
Pilot plant steam generator boasts control. M. S. Schwartz (D. N.) (chart) ..... Apr. 4 158
Thermoelectric generator put on sale by British firm (N) ..... Feb. 8 62
Glass
Glass flakes in resin make a strong, new coating (tables) ..... Sept. 5 *162
Glass pillows, balls find varied industrial uses ..... June 13 *100
Sightglass—"quickie" sightglass for pilot plant reactor. R. E. Leonard (D. N.) ..... June 27 *138
Glass Fibers
Fiber-glass containers for rockets' gas ..... Sept. 19 *114
Glass-cloth filter bags clean hot gas (N) ..... Jan. 25 *53
Impregnated glass fiber for tank manufacture ..... July 25 80
Market's rate of growth quickens ..... Aug. 8 72
Glycerine—Synthetic glycerine—Propylene sires new hopefuls. Messing & Bradley ..... Sept. 5 68
Glycol
Butenediol, unsaturated glycol, available in quantities ..... Nov. 28 96
Butylene glycol goes commercial at Celanese Corp. Bishop, Tex. complex (N) ..... Nov. 28 *76
Silicone-glycol aids cell structure of plastic foam ..... Mar. 7 *80
Gold
Golden Cycle Corp's novel finishing step boosts recovery (N) ..... Jan. 11 44
Resin scavenges gold from waste streams (N) ..... Nov. 28 78
Graphite
Armour process slashes molding time (N) ..... Sept. 5 52
Metal-bonded graphite materials ..... Nov. 28 164
Recrystallized graphite approved for rocket nozzle inserts (N)..... Nov. 14 114
Grinding—Powdered polyethylene produced by new process (N)....Mar. 21 82
Gypsum—Calciner streamlines gypsum process at Western Precipitation Corp. (chart) ..... Dec. 26 41

H

Heat
Ammonia converter design includes new heat-recovery system (chart) (N) ..... Aug. 22 60
Chart finds heat loss rate. J. F. Kuong (D.N.) ..... July 25 *146
How to calculate heat, water losses in metallurgical processing. B. L. Thomas (charts) ..... Aug. 8 *129
Heat Exchangers
Air-cooled heat exchanger solves freshwater problem (N) ..... Oct. 3 *44
Air-cooled heat exchangers—improving design. Collins & Mathews...May 16 *137
Costs see under **"Chemical Engineering" Cost File**
Design of air-cooled heat exchangers. F. L. Rubin ..... Oct. 31 *91
Guide to the anatomy of shell-and-tube heat exchangers. Drake & Carp (charts & table) ..... Apr. 18 165
Mechanical and economic features of principal heat exchanger designs (table) ..... Apr. 18 168
U-tubes—find effective length in exchanger design. Whitley & Ludwig (chart & tables) ..... June 27 111
Heat Transfer
Film coefficients in agitated systems. E. J. Ackley (charts & tables) ..... Aug. 22 133
Finned tubes can save money under fouling conditions. W. O. Webber (table) ..... Mar. 21 *149
Interpreting dimensionless groups. L. C. Tao ..... Nov. 28 129
Jacketed vessels get design improvements. C. A. Feichtinger (chart & table) ..... Sept. 5 *127
Review heat transfer principles—CE Refresher. Coates & Pressburg (charts & tables)
Match heat transfer principles to your exchanger needs ..... Jan. 25 *101
How heat transfer occurs in evaporators ..... Feb. 22 *139
Multiple-effect evaporators..Mar. 21 *157
Shell-side heat-transfer coefficient. T. J. Browder (chart) (D.N.) ..... Oct. 17 206
Unsteady-state heat transfer. Davis & Akers Pt 1 Apr. 18 *137, Pt 2 ..... May 16 *151
Unsteady-state heat transfer. B. H. Davis, Jr.
Pt 3 Use numerical methods of analysis (tables) ..... June 13 213
Pt 4 Use numerical mathematics ..... July 11 135
Pt 5 Numerical mathematical analysis ..... Aug. 8 *137
Heating
Prospects for nuclear process heat. Wright & Smith (charts & tables) ..... Nov. 28 *123
Pump balances space heat in new facility (N) (chart) ..... Mar. 7 61
Helium
Helium extracted from natural gas at Keyes, Okla. plant eases shortage—flowsheet ..... July 25 *96
Industrial gases ride technology boom. J. B. Bacon (charts & table)..Jan. 11 *54
Liquefaction to be put on large scale (N) ..... June 27 63
Liquid helium set for private production at Air Products' Iselin, N. J. plant (N) ..... May 2 66
Private firms to get into helium (N) ..... Oct. 31 48
Hexamethylenetetramine goes commercial ..... Oct. 3 *64
Hydrocarbons
Beware detonations ..... Jan. 11 *105
Injection system lets oxygen replace air in oxidizing hydrocarbons (chart) (N) ..... Oct. 17 *92
Pilot plant is new hope for tapping oil sands (N) ..... Feb. 22 *66
Refrigeration boosts LPG recovery in Lacq area, France (chart) (N) ..... Sept. 19 96
Hydrochloric Acid—Railway tank car can transport liquid HCl in bulk (N) ..... Aug. 22 58
Hydrogen
Cryogenerator produces hydrogen from ammonia right in the plant (chart) (N) ..... Aug. 22 *54
Distillation of H_2 for heavy-water on stream in France (N) ..... Mar. 21 *92
Hydrogen plasma serves as radar oscillator (N) ..... May 16 86
Industrial gases ride technology boom. J. B. Bacon (charts & table)..Jan. 11 *54
Liquid hydrogen—How the Air Force liquefies hydrogen—flowsheet..Jan. 25 *86
Liquid hydrogen—Linde Co. ventures first private commercial production—flowsheet ..... Oct. 17 *164
Liquid H_2—new details round out the story (N) (chart) ..... Feb. 22 *61
Liquid hydrogen-nuclear rocket work advances (N) ..... June 27 72
Liquid hydrogen to be produced by Air Products (N) ..... May 2 66
Palladium alloy used for hydrogen purification ..... Aug. 8 *78
Pressure lowers electrolytic H_2 cost (N) (chart) ..... Mar. 7 *66
Which process best for producing hydrogen? G. R. James..... Dec. 12 *161

I

Index—new firm to publish chemical index (N) ..... Mar. 7 60
Ink—Aromatic ketone improves printing inks ..... Dec. 12 98
Inorganic Chemicals
Inventory of new plants and facilities ..... Apr. 18 173
Inventory of new processes and technology ..... May 2 106
Inventory — semiannual inventory of new plants and facilities..... Oct. 17 174
Insecticides
Microbial insecticide called Thuricide (chart) (N) ..... Oct. 3 *42
Miticide to aid fruit growers...May 16 *94
Silica dust used for new insecticide, Dri-Die ..... Oct. 17 114
Instruments
Better forecasts of instrument sales (tables) ..... Mar. 7 72
Better information retrieval—60's challenge report ..... Jan. 11 100
CE Cost File 22. Process control instrumentation. Vilbrandt & Dryden ..... Jan. 11 124
CE Cost File 23. Estimating process instrumentation. J. W. Bernard ..... Jan. 25 120
Colorimeters prevent mixing of dielectric liquids. Kinney & Burnett (chart) (P.N.) ..... Mar. 21 *167
Information retrieval—what will it do for the chemical engineer? J. W. Perry ..... Dec. 26 88
Light amplifier called at "laser" (N) ..... Sept. 5 *52
Maintenance—rate instruments for maintenance costs. A. T. Sherman (charts) ..... Mar. 21 178
Maintenance—reduce costly down time. H. M. Schenk ..... Apr. 4 *164
Particle counter detects personnel and vehicle movements (N) ..... Oct. 3 46
Scales—weighing for process control. R. Y. Moss ..... Aug. 8 *147
Signal simulator speeds effluent treater maintenance (charts) (N)....Sept. 5 54
Spectrometer probes heart of matter (N) ..... Sept. 5 52
Viscometry—guide to industrial viscometry. R. L. Bates (charts)....Apr. 4 145
Insulation
Cryogenic insulation helps store volatile liquids ..... June 27 84
Fill called Perlox for cryogenic applications ..... Aug. 22 82
Plastics fibers, resins blended for electrical insulation ..... Apr. 18 112
Polyester wire enamel shows high heat resistance ..... Mar. 21 104
Polyurethane foam for insulation ..... Nov. 28 98
Intermediates
"Double-barreled" allylic chloride ..... Jan. 11 64
Lactonitrile—versatile compound ..... Oct. 17 112
Inventories—Scientific inventory control. Mayer & Taylor (chart)..... June 27 *140
Ion Exchange
Cation resin cleaner ..... Nov. 28 98
Ion exchange becomes powerful processing tool. Seamster & Wheaton..Aug. 22 115
Pickle liquor recovery process, using anin exchange membranes, proves uneconomical (N) ..... Apr. 4 66
Resin scavenges gold from waste streams (N) ..... Nov. 28 78
Iron
H-Iron process—making iron in a fluidized bed—flowsheet ..... Feb. 8 *96
Nu-Iron process—U. S. Steel's fluid-bed reduction process (N)..... Apr. 4 *64
Oxide blades cause corrosion...Sept. 5 *166
Pelleting step in Orcarb process promotes high prereduction of iron ore (N) ..... June 27 *68
Recovered from waste pickle liquor by new mercury cell process (chart) (N) ..... May 16 82
Isophthalic gains via phthalic shortage ..... Oct. 17 108
Isoprene — Polyisoprene — tree rubber's successors readied. Frances Arne (charts & tables) ..... Sept. 19 104

J

Joints—Use swivel joints for flexibility. G. M. Bagnard ..... Sept. 19 *175

K

Ketones
Aromatic ketone improves printing inks ..... Dec. 12 98
Secondary alcohols yield ketones in catalytic liquid process (N)...Feb. 8 *63
Kinetics
Interactions—how to evaluate interactions. C. A. Zapata (D.N.) (charts) ..... Apr. 4 160
Process kinetics can predict reaction mechanism. Henry Eyring (tables) ..... Dec. 26 83
Systems engineering. T. J. Williams. See under **Engineering**
Why not one expression for the rate of reaction? L. S. Kowalczyk....Oct. 17 *191

L

Labor
Capital cost estimates for process industries—report. J. W. Hackney (charts & tables) Pt 1 Mar. 7 113, Pt 2 ..... Apr. 4 *119
CE Cost File Labor factors see under **CE Cost File**
Engineers win benefits via one-week strike (N) ..... Aug. 22 62
Florida report on job opportunities for engineers (charts) ..... Oct. 3 126
NSPE's new policy on unions....May 2 128
The operating man. P. J. Brennan Sept. 5 *156
Politically active employees get time off with pay at Conoco (N)..June 27 63
Salary expresses quality — top pay, starting pay and your pay (chart & table) ..... July 11 140
Shift schedules. R. H. Wing (tables) Dec. 12 *182
Staffing new plants for startups. J. H. Riddle ..... Oct. 31 *126
Technical service—a job to consider. Lange & Crom..... Aug. 22 142

Law
Oyster growers demand stiffer pollution laws (N)..... Oct. 3 52
What engineers should know about patents and claims. Floyd Trimble Oct. 3 113
You must deliver competency and skill. A. W. Gray..... Mar. 21 *169

Leasing see **Equipment**
Leather—Tanning process prompts glutaraldehyde price cuts (N)..... Oct. 3 44

Lighting
Cellulose modified for electroluminescent lamps..... Sept. 5 72
Light amplifier called a "laser" (N) Sept. 5 *52

Lime—Neutralizing waste acids—know your chemicals, save money. H. L. Jacobs (charts)..... May 30 *87

Liquids
Air lift operates from syphon. A. A. Mayling (D. N.)..... Aug. 22 *152
Colorimeters prevent mixing of dielectric liquids. Kinney & Burnett (chart) (P. N.)..... Mar. 21 *167
Entrainment from perforated bubble trays at close spacings. L. Friend & others (charts & tables)..... Oct. 31 101
Fluorescent particles for tracing liquid flow. Merton Allen (D. N.)...June 27 136
Helium liquefaction to be put on large scale (N)..... June 27 63
How to predict ternary azeotropes. Imrich Klein..... Nov. 14 233
Hydrogen—How the Air Force liquefies hydrogen—flowsheet ..... Jan. 25 *86
Hydrogen—New details round out liquid H_2 story (N) (chart)..... Feb. 22 *61
Polybutene—Cosden's process licensed for export—flowsheet..... Aug. 8 *98
Urethane—liquid urethane promises many uses..... July 11 88
Viscometry—guide to industrial viscometry. R. L. Bates (charts) Apr. 4 145

Lubrication
Additives up resistance to cold..Jan. 11 64
Chemical lubes measure up. Frances Arne ..... Jan. 25 *62
Dow's Ambifio lubricants run gamut of services ..... Sept. 5 72
High vacuum solid film lubricant Jan. 11 62
Jet lube for high-temperature service May 2 82
Jet lube has good storage stability May 2 80
Lubricant for high temperature aircraft service..... July 25 80
Modified sperm oil emulsifies easily, protects metals..... Nov. 14 134
Molybdenum disulfide lubricant for extreme pressure applications...Mar. 21 102
MoS_2 paste boosts tool life by 300% Nov. 28 100
Teflon—aerosol-applied Teflon..Oct. 17 114

M

Maintenance
Be practical about safety. W. H. Richardson ..... July 11 *156
Budgeting maintenance costs. J. W. Clayton ..... Feb. 22 *156
Can maintenance infringe patents? Aug. 22 158
Chemical engineers find more room in maintenance ..... Jan. 25 126
Chemical engineers prominent in maintenance ..... May 30 120
Critical path saves time and money. R. C. Steinfeld (charts)..... Nov. 28 *148
Curing troubles with a long gage glass (P. N.)..... Mar. 21 168
Cut maintenance costs by cylinder care. P. C. Ziemke (P. N.)..... Jan. 25 *124
Disposable copies of maintenance forms make record-keeping painless. T. W. Hudson ..... Jan. 11 *134
Don't accept specification headaches. W. H. Richardson..... Feb. 8 *148
Effluent treater maintenance speeded by signal simulator (charts) (N). Sept. 5 54
Evaluating wear-resistant materials July 11 *162
Field repair method for leaking pipes uses epoxy resins..... Dec. 12 188
Finned tubes can save money under fouling conditions. W. O. Webber (table) ..... Mar. 21 *149
How to set up operator shift schedules. R. H. Wing (tables)..... Dec. 12 *182
Instruments—rate instruments for maintenance costs. A. T. Sherman (charts) ..... Mar. 21 178
Measuring and controlling maintenance costs. R. I. Reul (chart and tables) Sept. 19 203
Metavanadate: effective corrosion inhibitor ..... Oct. 3 134
Plastic caps add life to steel bolts July 25 *82
Quick way to check on mill scale removal ..... Oct. 3 134
Reduce costly down time. H. M. Schenk ..... Apr. 4 *164
Retraying bubble cap columns. James Tipton (charts & table)..... July 25 *134
Safety program is a full-time job. Edward Allen..... Nov. 14 *246
Scheduling keeps costs in line. H. L. Timmons ..... Mar. 7 *160
Silicone "raincoat" keeps masonry dry Sept. 5 *76
Silicones solve problems. B. P. Coe Aug. 22 *156
"Sniffer" locates leaks. J. Giladi (P. N.)..... Oct. 3 *118
Stabilizer-dispersant cuts refinery fouling ..... June 13 98
Stealing: what can you do about it? W. H. Richardson..... Oct. 17 *210
Stack inspection—crane eliminates scaffolding, saves time..... Apr. 18 *212

Management
Are we meeting the union challenge? E. A. Hartsook..... Feb. 22 145
Be kind to salesmen. W. H. Richardson ..... May 2 *144
Critical path saves time and money. R. C. Steinfeld (charts)..... Nov. 28 *148
Do you have a permanent job? Really? A. W. Gray..... Sept. 5 *142
Does your employer own your knowledge—follow-up report..... June 13 222
Employee communication—what makes Henry talk? D. J. Petruzzi..May 16 *147
Engineering or management careers—which grass is greener?..... July 25 127
Estimate working capital needs. L. R. Bechtel (table)..... Feb. 22 127
How to prepare for plant startups—report. J. E. Troyan (charts & tables) Sept. 5 *107
How to start out on the right foot. R. G. Powell..... Sept. 19 *209
The management function of the engineer in industry. H. S. Bunn..Nov. 14 *239
Materials control program for small plants. A. J. Bohl..... Apr. 18 *206
The operating man. P. J. Brennan Sept. 5 *156
Phillips Petroleum Co. wins NSPE award as best engineering employer June 27 *128
"Productivity" means many things Feb. 22 72
Rising costs demand engineer-managers —60's challenge report..... Jan. 11 101
A safety program is a full-time job. Edward Allen..... Nov. 14 *246
Salaries—total compensation of some top CPI executives (table)...July 11 140
Salaries—What basis for comparing salaries? R. F. Fremed (chart) Oct. 3 125
Score your executive attributes. R. S. Schultz ..... Oct. 31 131
Secretaries who talk your language Mar. 7 *148
Speeches—Beware of the expert speech makers. W. A. Sylvester..... Aug. 8 143
Speeches—the next talk you have to give. Lawrence Murphy..... Apr. 4 *151
Spying—the truth about industrial spying. R. A. Labine..... Feb. 22 *121
Staffing new plants for startups. J. H. Riddle ..... Oct. 31 *126
Stealing: what can you do about it? W. H. Richardson..... Oct. 17 *210
Use capital ratio. Lynn & Howland (charts & tables)..... Feb. 8 131
Marshall and Stevens indexes of comparative equipment costs Jan. 11 170, Jan. 25 152, Feb. 8 175, Feb. 22 191, Mar. 7 190, Mar. 21 210, Apr. 4 196, Apr. 18 250, May 2 171, May 16 204, May 30 137, June 13 266, June 27 174, July 11 189, July 25 172, Aug. 8 175, Aug. 22 187, Sept. 5 190, Sept. 19 255, Oct. 3 149, Oct. 17 254, Oct. 31 164, Nov. 14 285 Nov. 28 182, Dec. 12 222..Dec. 26 128
Marshall and Stevens annual indexes of comparative equipment costs 1913 to 1959 (charts & tables)..... Apr. 4 149
Mass transfer operations see also under **"Chemical Engineering Refresher"**

Materials Handling
Adhesive prevents slippage of palletized polyethylene bags..... Mar. 7 80
Bucket elevators—estimating costs. H. E. Mills (charts & tables). Nov. 28 *117
Bulk handling system for polystyrene cuts resin cost (N)..... Nov. 28 *86
Canada's waste wood to move in plastic spheres (N)..... Jan. 11 50
Tankers: stainless to plastic gamut Jan. 25 *130

Materials of Construction
Aluminum roof protects water reservoir Apr. 18 *218
Brick-lined process equipment. Donald Thompson.
Pt 1—How to select and design (charts & table)..... Feb. 22 *129
Pt 2—Designing details (charts) Mar. 21 *161
Cement outlook: grim but hopeful. F. C. Price (chart)..... Oct. 31 *60
Ceramic-coated metals handle much higher temperatures than glassed steel (charts & table)..... Oct. 3 130
Exotic metals become plentiful in rod and tube forms..... Sept. 19 *222
Fiber board from wood chips, sulfite liquor (N)..... Aug. 8 62
Geon—vinyl, called hi-temp Geon, may move in on metals..... June 27 *82
Geon-coated nylon builds air-supported structures ..... July 25 *78
Low-temperature construction materials (charts & tables)
Carbon steels. R. W. Vanderbeck May 30 *103
Alloy steels. Rote & Proctor..June 27 *119
Stainless steel. McConnell & Brady July 11 *125
Nickel steel alloys. R. J. Johnson July 25 *115
Aluminum alloys. E. W. Johnson Aug. 8 *133
Copper and its alloys. C. L. Bulow Sept. 19 *187
Low-temperature metals: a roundup. G. H. Zenner..... Oct. 31 *117
Materials of construction—19th Biennial report (tables)
Selecting materials for process piping. C. K. Aldrich..... Nov. 14 *183
Directory of manufacturers..Nov. 14 193
Inventory of current literature Nov. 14 214
Metal-bonded graphite materials Nov. 28 164
Metallic coatings and surfacing methods for high-temperature processes. J. R. Schley (chart & table)..Mar. 21 *184
Paving materials colored by plastic binders ..... Apr. 4 *88
Plastic beats metal as rocket casing (N) ..... Oct. 3 46
Pipeline market stirs materials battle (N) ..... May 30 50
Plastics for linings get shape "memory" with Gamma radiation..Aug. 22 80
Plastics make a dent in paper markets. G. B. Hegeman (table)..... May 16 88
Polycarbonates: thermoplastics for the '60s ..... Oct. 31 68
Polyethylene noses out steel for gas pipeline (table)..... May 30 124
Polyethylene—stabilized poly extruded to weather-resistant film..... May 16 98
Reinforced plastic beats steel for storage tanks (table)..... Apr. 18 *214
Reinforced plastics for equipment may take big leap (chart)..... Oct. 17 *104
Stainless—stronger cast stainless alloy keeps promises. E. A. Schoefer (tables) ..... Mar. 7 164
Steel—new, lighter, stronger carbon steel ..... Sept. 19 220
Steel—tougher steels for process equipment (N)..... Oct. 31 54
Sulfuric-resisting alloys-corrosion data. Schillmoller & LaQue (chart & table) Apr. 4 170
Tankers: stainless to plastic gamut Jan. 25 *130
Tantalum touted for low-temperature service ..... May 30 126
Thermoelectric material shows high energy-conversion efficiency...Oct. 17 110
Zirconium—higher purity boosts resistance. W. E. Kuhn (chart & tables) Feb. 8 *154

Measurements
Dust counter detects personnel and vehicle movements (N)..... Oct. 3 46
Flow—Better way to measure two-phase flow. Moye Wicks III (P. N.) July 11 *152
Taking roof tilt out of gaging (P. N.) Aug. 8 *146
Melamine monopoly charged by government (N)..... Nov. 14 132
Mercury cell process regenerates waste pickle liquor acid, recovers iron (chart) (N)..... May 16 82

Metallurgy
Aluminum process shakeup brewing (chart) (N)..... Oct. 17 90
Clad metal made by extrusion..May 30 126
Golden Cycle Corp.'s novel finishing step boosts gold recovery (N).Jan. 11 44
How to calculate heat, water losses from heated ponds and thickeners. B. L. Thomas (charts)..... Aug. 8 *129
Steel—open-coil process produces better steel sheet for less (N)..... Aug. 22 *58

Metals
Bromine corrosion—moisture the key enemy. Lake & Gunkler..... Oct. 31 *136
Ceramic-coated metals handle much higher temperatures than glassed steel (charts & table)..... Oct. 3 130

NOTES—(D.N.) Design Notebook; *Illustrated; (N) News; (P.N.) Plant Notebook

Clad metal made by new extrusion technique ..... May 30 126
Coatings and surfacing for high-temperature processes. J. R. Schley (chart & table) ..... Mar. 21 *184
"Common" metals' temperature and strength limits extended (N). Mar. 21 84
Exotic metals become plentiful in rod and tube forms ..... Sept. 19 *222
Inhibitive primer shields metal surfaces ..... June 13 *98
Inventory of new plants and facilities ..... Apr. 18 176
Inventory of new processes and technology ..... May 2 110
Inventory—semiannual inventory of new plants and facilities ..... Oct. 17 175
Lead-bonded metals shield radioactive corrosives (table) ..... Nov. 14 *252
Low-temperature construction metals (charts & tables)
Carbon steels. R. W. Vanderbeck ..... May 30 *103
Alloy steels. Rote & Proctor. June 27 *119
Stainless steel. McConnell & Brady ..... July 11 *125
Nickel steel alloys. R. J. Johnson ..... July 25 *115
Aluminum alloys. E. W. Johnson ..... Aug. 8 *133
Copper and its alloys. C. L. Bulow ..... Sept. 19 *187
Roundup. G. H. Zenner ..... Oct. 31 *117
Ni-Al coatings on metals resist oxidation ..... Oct. 31 140
Promising extrusion of refractory metals ..... Jan. 25 134
Refractory sheet developments—pace quickens (table) ..... Nov. 14 256
Scandium—pound of rare metal produced for Air Force ..... Mar. 21 *102
Small grain size improves refractory metals ..... Nov. 14 254

Meters
Flowmeter is maintenance-free. Butler & Nippe (P. N.) ..... Feb. 22 *154
Home-made hygrometer. E. J. Gibbons (P. N.) ..... Nov. 28 *144
Viscometers—industrial types, ranges and applications (table) ..... Apr. 4 147

Methane
Chemicals from methane—Petrochemicals Pt 2. Messing & Bradley (tables) ..... June 27 74
Cryogenics moves in on methane—flowsheet ..... Sept. 5 *98
Shell joins transoceanic liquid methane shippers (N) ..... Mar. 7 70

Mexico
Chemical men look south of the border. F. B. Loretta ..... Feb. 8 74
Mexican chemicals thrive. F. Loretta ..... Feb. 22 76
Petrochemical plans include foreign aid to other Latin American countries ..... Dec. 26 46

Mixing
Corrosion-control design. N. H. Parker ..... Dec. 12 *190
Guides to reducing agitator failures ..... Dec. 26 *112
Fabrication: key to mixer corrosion ..... May 2 *61
Rocket propellant—Aerojet's process brings "stream" techniques to paste mixing (N) (chart) ..... Nov. 28 *84
Special-purpose speeds mix formula calculating for H. P. Hood & Sons (N) ..... Dec. 26 46

Models—Interpreting dimensionless groups. L. C. Tao ..... Nov. 28 129

Molding
Chemical sieve material controls molding of urethane foams ..... June 27 86
Epoxies suitable for high-speed molding ..... Apr. 4 88
Shoemaking—one-step injection molding permanently bonds sole and upper (N) ..... Sept. 19 96
Silicone solution cuts cleaning time in shell molding ..... Oct. 3 62
Teflon molding process uses controlled squeezing ..... Dec. 26 46

Motors
CE Cost File Labor factors. E. W. Michel
30. A. c. motor starters ..... May 2 142
34. Motor starters ..... June 27 134
38. A. c. and d. c. motors ..... Aug. 22 148
Choosing drivers for centrifugal compressors. F. L. Gillett (table) .. Mar. 7 143

N

Naphthalene
Oil-based aromatics gain first place. Messing & Bradley (tables) .. Dec. 26 50
Oil refiners rush to produce aromatics (table) (N) ..... Oct. 17 100
Source—new process shifts from coal to petroleum (N) ..... June 13 82

Naphthoquinone—1, 4-naphthoquinone available in pure form ..... Apr. 4 90

Natural Gas
Fluor uses new solvent to lower gas-treating cost (chart) (N) .... May 30 *46
Haines sulfur recovery process goes into pilot plant (N) ..... Dec. 12 *86
Helium contracts will go to private natural gas firms (N) ..... Oct. 31 48
Helium extracted from natural gas at Keyes, Okla. plant—flowsheet. July 25 *96
Inventory of new plants and facilities ..... Apr. 18 176
Inventory of new processes and technology ..... May 2 114
Inventory—semiannual inventory of new plants and facilities ..... Oct. 17 177
Jet engine grounded to drive pipeline compressor—a first in transmission ..... Dec. 26 *42
Sweet-gas by the Giammarco-Vetrocoke process makes U. S. debut—flowsheet ..... Sept. 19 *166

Nickel
Nickel steel alloys for low-temperature construction. R. J. Johnson (charts & tables) ..... July 25 *115
Solvent extraction for cobalt-nickel separations works at Dow (N). Apr. 4 66

Nitric Acid—Concentration—new two-column process (N) (chart) .... Apr. 18 94

Nitrogen—Industrial gases ride technology boom. J. B. Bacon (charts & table) ..... Jan. 11 *54

Nitrogenation—Finer feed improves nitrogenation in rotating-furnace technique (N) ..... Feb. 8 *66

Nitrous Oxide—Mobile plant designed for Army (N) ..... June 13 *84

Nylon
Dracone, nylon-rubber barge, makes U. S. debut (N) ..... June 27 *62
Massive nylon shapes produced for first time by Polymer Corp ..... Feb. 22 *78
Nylon film ..... Jan. 11 *60
Nylon-6 for tire cord—production expansion slated (N) ..... May 2 66
Vinyl-coated nylon for air-supported structures ..... July 25 *78
"Welded" to metal with epoxy bonding agent ..... Oct. 3 64

O

Oils and Fats
Animal fats—low price ups animal fats' share of fats and oils markets (chart & tables) ..... Nov. 28 90
Fatty hydroxamic acids, useful intermediates ..... Dec. 26 62
Foreign fatty acid plant will use ozone splitting (N) ..... Feb. 8 72
Optimization—More from less with optimization—60's challenge report ..... Jan. 11 92

Organic Chemicals
Chemurgy now promises attractive profits. R. P. Windisch (table & chart) ..... June 13 94
Inventory of new plants and facilities ..... Apr. 18 173
Inventory of new processes and technology ..... May 2 103
Inventory—semiannual inventory of new plants and facilities ..... Oct. 17 175
1, 4-naphthoquinone now available in pure form ..... Apr. 4 90

Oxidation
Inhibitors—antioxidants for resins ..... Feb. 22 80
Injection system lets oxygen replace air in oxidizing hydrocarbons (chart) (N) ..... Oct. 17 *92
Nickel-aluminum coatings on metal resist oxidation ..... Oct. 31 140

Oxygen
Industrial gases ride technology boom. J. B. Bacon (charts & table) .. Jan. 11 *54
Steelmaking revolution: the blast furnace (N) ..... Nov. 28 *77

P

Packaging
Cellophane that seals at much lower temperature ..... June 13 96
Containers for chemicals—report. T. E. Dowling (tables) ..... Oct. 3 *85
Fluorohalocarbon films for low temperature absorption ..... Aug. 8 *76
Multiwall paper containers. T. E. Dowling (tables) Pt 1 May 16 *164, Pt 2 ..... May 30 *116
Plastics make a dent in paper markets. G. B. Hegeman (table) ..... May 16 88
Polyethylene film combines transparency and strength ..... Aug. 8 *76
Polypropylene film promises to benefit packagers ..... May 30 *62
Polystyrene foam, Dyna-Foam, threatens paper ..... Oct. 3 *62

Paints
Lecithin concentrate helps stabilize water-based paints ..... May 30 64
Primers—Reilly's quick-drying red and alkali-resisting white ..... July 11 86

Palladium alloy used for hydrogen purification ..... Aug. 8 *78

Paper
Drying speeded with new high-velocity, air-shrouded dryers (N) (table) ..... June 13 *79
Expanded polystyrene threatens paper ..... Oct. 3 *62
Ion exchange papers for meld with chromatography ..... May 16 96
Latex—new coating material .... May 2 78
Plastics make a dent in paper markets. G. B. Hegeman (table) ..... May 16 88
Waterproofing resin cuts paper mills' resin needs ..... June 13 96

Patents
Can maintenance infringe patents? ..... Aug. 22 158
Polypropylene patents OK'd by Japanese (N) ..... Nov. 28 76
Read government research contracts carefully ..... Oct. 31 66
What engineers should know about patents and claims. Floyd Trimble ..... Oct. 3 113

Pellets
Fertilizer pelletizing—two new approaches at Calspray plant—flowsheet ..... Aug. 22 *106
Iron—pelleting step in Orcarb process promotes high prereduction of iron ore (N) ..... June 27 *68

Perchloroethylene—Propylene sires new hopefuls. Messing & Bradley (table) ..... Sept. 5 64

Petrochemicals
Australia adds petrochemicals to chemical boom ..... Oct. 3 *58
Flow chart—industry outline shows how products recur, identifying economic choices. Messing & Bradley .. May 30 54
Japan doubling capacity for key petrochemicals ..... Dec. 26 40
Mexico adds foreign aid to petrochemical plans ..... Dec. 26 46
Mexico's Pemex sets up petrochemical reserve (N) ..... June 13 78
Oil-based aromatics gain first place. Messing & Bradley (tables) .. Dec. 26 50
Oil refiners rush to produce aromatics (table) (N) ..... Oct. 17 100
Petrochemicals. Messing and Bradley
1 An industry maps its mature years (chart) ..... May 30 54
2 Chemicals from methane (tables) ..... June 27 74
3 Ethylene copes with growing competition (tables) ..... Aug. 22 66
4 Propylene sires industry's new hopefuls (tables) ..... Sept. 5 60

Petroleum
Additives, Paradyne HO-10 and HO-20 1 lower pour point of heating oils ..... Nov. 14 134
Alkylation unit yields dual benefit—flowsheet ..... Dec. 12 *132
Cat cracker at Esso Standard refinery shatters world on-stream record (N) ..... Mar. 7 *64
Computer controls crude distillation at Standard's Whiting, Ind., refinery (N) ..... Oct. 31 48
Equations predict cracked product yields (N) ..... Jan. 25 52
Fluid coking costs down, profits up—flowsheet ..... May 16 *112
Inventory of new plants and facilities ..... Apr. 18 176
Inventory of new processes and technology ..... May 2 112
Inventory—semiannual inventory of new plants and facilities ..... Oct. 17 177
Oil—the squeeze comes in the '60's. J. B. Bacon (tables) ..... Mar. 21 96
Pilot plant is new hope for tapping oil sands (N) ..... Feb. 22 *66
Trickle desulfurizing process cleans up distillates at Shell refinery—flowsheet ..... Oct. 3 *76

Phosphate
Alkyl phosphates stabilize polymerizations ..... Nov. 14 136
New sources of fluorine (N) (chart) ..... Dec. 12 79

Phthalic anhydride—Oil-based aromatics gain first place. Messing & Bradley (tables) ..... Dec. 26 50

Pipes
Acetylene transmission piping systems—safety aspects of design (charts) ..... Sept. 5 *131
Balls replace dumbbells for separating products in 250-mile Shell pipeline (N) ..... Jan. 11 *45
Benzene pipeline design prevents freezing during severe winter weather (N) ..... Feb. 8 *70
CE Cost File 47: Ductwork. R. T. Witherspoon ..... Dec. 26 110
Corrosion—onstream check uses gamma rays and film ..... May 30 *122
Epoxy-glue pipe joint avoids expensive welds ..... Nov. 28 *160
Field repair method for leaking pipes uses epoxy resins ..... Dec. 12 188
Flow of fluids design—report. E. E. Ludwig (charts & tables) ..... June 13 *161
Internal coating of large pipe at A. O. Smith ..... Nov. 28 *162
Materials battle for pipeline market (N) ..... May 30 50
Plastic pipe withstands fire (N) . Mar. 21 82
Plastic pipes made of isophthalic resin ..... Sept. 5 *74
Plastic piping and tubular netting extruded directly ..... July 11 *88
Polyester ductwork replaces corroded iron pipes ..... July 11 *90
Polyethylene noses out steel for gas pipeline (table) ..... May 30 124
Polyethylene pipe standards May 2 60, Oct. 3 134
Prestressed concrete pipe gains favor as storage tanks ..... July 11 *164
Resonance bending tests metal pipe (N) ..... May 2 *60

NOTES—(D.N.) Design Notebook; *Illustrated; (N) News; (P.N.) Plant Notebook

Selecting materials for process piping. C. K. Aldrich....Nov. 14 *183
Sewers—How to size conduits for storm sewers. C. A. Lee (chart & tables) Oct. 3 97
Swivel joints provide flexibility. G. M. Bagnard....Sept. 19 *175
Underground fueling system for jet aircraft uses largest aluminum pipe Nov. 28 *164

Plant Location
Concentration points of U. S. CPI plants (table)....Sept. 19 108
Plant site, layout minimize corrosion. R. B. Mears (tables)....Jan. 11 *144

Plant Notebook
Automatic switch for cooling water. R. L. Smith (chart)....Apr. 18 196
Better way to measure two-phase flow. Moye Wicks III....July 11 *152
Better way to read emergency delta P's. W. L. Scheirman....June 13 236
Blowcase for pumping slag wool slurries. C. E. Billings & others (chart) Oct. 31 121
Breakproof gage glass of plastic in a metal tube. R. E. Leonard...Nov. 28 *143
Check for vacuum producers. E. F. Harp....May 16 *162
Chart speeds calculation of economic batch size. H. C. Schweyer (chart) Sept. 5 152
Colorimeters watch for wrong connection. Kinney & Burnett (chart) Mar. 21 *167
Constant rate lab feeder. C. F. A. Roberts....Dec. 26 107
Curing troubles with a long gage glass. T. H. Anderson....Mar. 21 168
Cut maintenance costs by cylinder care. P. C. Ziemke....Jan. 25 *124
Easy way to stop discharge vortexing. R. D. Connolly....Sept. 5 154
Emergency repair for an oleum outlet valve. J. X. F. Smith....July 11 154
Flowmeter is maintenance-free. Butler & Nippe....Feb. 22 *154
For batching use hydraulic paradox. A. W. Billitzer (chart)....Jan. 25 122
Four-way valves provide foolproof piping system. D. B. Milholland...Oct. 3 *117
Home-made hygrometer E. J. Gibbons Nov. 28 *144
Interface control using thermistors. Frederick Fahnoe (chart)....Feb. 22 153
Liquid seal will prevent overpressure. Leonard Steber....Apr. 18 *198
Nomograph for excess air. F. Caplan Oct. 31 *122
Priming a worn pump. M. Gluckman Nov. 28 *143
Process variables by chart....Dec. 26 *108
Quick way of finding net positive suction head (NPSH). M. Fridman Oct. 31 122
Repair filter weaves by fabric "welding". R. W. Moore....Aug. 8 146
Simple chain scraper for dry dust collectors. A. J. Stewart....July 11 *154
"Sniffer" locates leaks. J. Giladi Oct. 3 *118
Steam cuts NO content of inert gases. T. W. Miller....June 13 *234
Taking tilt out of gaging....Aug. 8 *146
Temperature checkup shows which valves leak. K. H. Parekh....Nov. 28 144
Temporary dust collector saves two months' time. T. M. Sheets...Oct. 31 *122
Thermistor level control works in difficult service. R. E. Hudrlik (chart) May 16 160
Transparent nomogram is handy for operation. G. L. Head....June 13 236
Water flow controls time-delay relay. Sideman & Giladi....Aug. 8 *145
Wrench—big lift for a heavy wrench Oct. 3 *118
Y-Splitter improves gassing of samples. R. W. Moore....June 13 236

Plants
CE Cost File 31. Chemical plant cost breakdown. Haselbarth & Berk May 16 158
Contract for nuclear plant agrees to fixed cost, penalties for late delivery (N)....May 16 82
Desalting—rundown on processes for government's 5 demonstration plants (table)....July 25 *105
Diamond Alkali's new caustic-chlorine cell room cost only 14 days downtime (N)....May 30 *42
Hints for plant startup. J. E. Troyan Part I Troubleshooting new processes Nov. 14 *223
Inventory of new plants and facilities (tables)....Apr. 18 171
Inventory—semiannual inventory of new plants and facilities....Oct. 17 173
Staffing new plants for startups. J. H. Riddle....Oct. 31 *126
Startups—how to prepare for CPI plant startups—report. J. E. Troyan (charts & tables)....Sept. 5 *107
Systems engineering. T. J. Williams. See under **Engineering**

Plasticizers—Polymeric ester speeds vinyl formulations....Nov. 14 134

Plastics
Breakproof gage glass of plastic in a metal tube. R. E. Leonard (P.N.) Nov. 28 *143
Coating material for electronic parts May 16 *98
Conduits—ABS polymer for electrical conduits....May 2 *78
Fluorohalocarbon films for low temperature absorption....Aug. 8 *76
Fluors—scintillation fluors, largest ever made, detect radiation....Mar. 21 *106
Gamma radiation treatment gives plastics shape "memory"....Aug. 22 80
Germans import, export more plastics Sept. 5 70
Glass-reinforced plastic corrosion-resistant equipment may take big leap (chart)....Oct. 17 *104
Inventory of new plants and facilities Apr. 18 179
Inventory of new processes and technology....May 2 115
Inventory—semiannual inventory of new plants and facilities....Oct. 17 175
Isophthalic resin pipes....Sept. 5 *74
Kynar-Pennsalt's thermoplastic resin Dec. 26 *64
Larger plastic molded articles made with Spencer Chemical Co.'s process (N)....Mar. 7 68
Microballoons cut evaporation loss (N) Dec. 12 88
Netting—tubular netting extruded directly....July 11 *88
Paraline RD polyvinyl chloride plastic—seamless coating for acid tanks Nov. 28 *96
Pipe made of Buton withstands fire (N)....Mar. 21 82
Pipe plastic coated at A. O. Smith plant....Nov. 28 *162
Plastic bests metal as rocket casing (N)....Oct. 3 46
Plastic caps add to life of steel bolts July 25 *82
Plastics make a dent in paper markets. G. B. Hegeman (table)....May 16 88
Polycarbonates—GE's Mt. Vernon, Ind. plant—flowsheet....Nov. 14 *174
Polyester ductwork replaces corroded iron pipes....July 11 *90
PVC—Ethylene copes with competition—outlook, capacity, end-uses. Messing & Bradley (tables)....Aug. 22 70
PVC stabilizers help vinyl processing Apr. 4 90
Polyvinyl dichloride, called hi-temp Geon, may move in on metals June 27 *82
Reinforced polyester for low cost jet engine housings....Jan. 25 *70
Resins stripped of solvents by new process (N)....May 30 52
Russia stresses plastics technology (N) Aug. 8-70, Aug. 22 64
Seek rocket casing, jet engine jobs (N) Feb. 8 68
Tankers: stainless to plastic gamut Jan. 25 *130
Two winners, no losers in plastics record (N)....Feb. 22 60
UV absorber light stabilizes polyolefin plastics....June 27 82

Plating
Superfluidity: key to plating, welding routes? (N)....Jan. 25 52
Tungsten coatings are now easier to apply....Mar. 7 *78
Polybutene—Cosden Petroleum's liquid polybutene process licensed for export—flowsheet....Aug. 8 *98

Polycarbonates
Making polycarbonates: a first look—GE's Mt. Vernon, Ind., plant—flowsheet....Nov. 14 *174
Outlook: markets up, prices down Oct. 17 108
Polycarbonate polyesters for stable photo film base....Apr. 4 88

Polyethylene
Ameripol, high-density polyethylene Dec. 26 *63
Competes favorably with steel for gas pipeline (table)....May 30 124
Ethylene copes with competition—capacity, outlook, end-uses. Messing & Bradley (tables)....Aug. 22 68
Film combines transparency and strength....Aug. 8 *76
Goodrich-Gulf and Owens-Illinois announce polyethylene plans (N) Jan. 11 52
Larger molded articles made with Spencer Chemical Co.'s new process (N)....Mar. 7 68
Linear polyethylene via the Phillips process—flowsheet....Apr. 4 *110
Low molecular weight....Jan. 25 *70
Mulch speeds tree growth....Apr. 4 *92
Pipe—standards for polyethylene pipe May 2-60, Oct. 3 134
Polyethylene-saran films....Dec. 12 *98
Powdered polyethylene called Microthene (N)....Mar. 21 82
Resin for greaseproof coatings, heat seals....Apr. 18 110
Shrinkable—Irradiated film has high-heat shrinkability (N)....Apr. 18 *92
Stabilized polyethylene can be extruded to film....May 16 98
Two winners, no losers in plastics record (N)....Feb. 22 60

Polypropylene
Japan readies full-scale push into polypropylene (N)....Apr. 18 94
Patents okayed for Japanese (N) Nov. 28 76
Polypropylene film promises to benefit packagers....May 30 *62
Propylene sires new hopefuls—capacity, outlook (table). Messing & Bradley Sept. 5 62
Texas Eastman, Longview, Tex., plant under construction (N)....Jan. 25 60
Ziegler process at Humble's Baytown, Tex., refinery promises big-volume production—flowsheet....Jan. 27 *96

Polystyrene
Bulk handling system cuts resin cost at Sperzel Co. (N)....Nov. 28 *86
Expanded polystyrene, Dyna-Foam, threatens paper....Oct. 3 *62
Plant will be delivered to the USSR (N)....Jan. 11 44

Polyurethane
Abrasion-resistant polyurethanes July 25 78
Foam see under **Foams**
Urethane—liquid urethane promises many uses....July 11 88
Potash—Biggest mine, part of Texas Gulf Sulfur's Utah venture (N)....Oct. 31 *48

Powder Metallurgy
Alumina excels conventional potting compounds....Jan. 25 *72
Ductile alloys produced by novel technique....Aug. 8 *158
Iron—H-iron process makes iron in a fluidized bed—flowsheet....Feb. 8 *96
Iron—Nu-Iron, U. S. Steel's fluid-bed process, (N)....Apr. 4 *64
High purity metals now available as powder....Jan. 11 62
Molybdenum-tungsten alloy powders Dec. 12 102
Spherical bead powders serve as rocket fuel additive....Sept. 5 *72

Pressure
CE Cost File 35. Estimating pressure vessels. A. J. Reilly (charts)..July 11 146
How to design a pressure relief system. Joseph Conison (charts).July 25 *109
How to select pressure-vessel size. R. R. Maccary (charts & table) Oct. 17 187
Jacketed vessels get design improvements. C. A. Feichtinger (chart & table)....Sept. 5 *127
Lowers electrolytic H_2 cost (N) (chart) Mar. 7 *66
Pressure vessel design for high or cryogenic temperatures. R. R. Maccary (charts)....Nov. 28 131
Ultrahigh pressure reached by new Battelle Memorial device (N)..Apr. 4 68
Vapor pressure of organics. W. Shulman (D.N.)....Dec. 12 180
Printing plate of photopolymer—called "Dycril" (N)....Mar. 7 60

Production
Don't accept specification headaches. W. H. Richardson....Feb. 8 *148
Evoluntionary operations can optimize your chemical process. J. S. Hunter (charts & tables)....Sept. 19 193
How to set up operator shift schedules. R. H. Wing (tables)....Dec. 12 *182
The operating man. P. J. Brennan Sept. 5 *156
Plant startups. J. E. Troyan
How to prepare for plant startups—report....Sept. 5 *107
Hints for plant startup
Part I Troubleshooting new processes....Nov. 14 *223
"Productivity" means many things Feb. 22 72
Scheduling maintenance keeps costs in line. H. L. Timmons....Mar. 7 *160
Tower-lining scheme cuts expansion downtime (N)....Oct. 3 *50

Propane—Cavern under Sun Oil's Marcus Hook refinery will store liquified propane....Dec. 26 *40

Propylene
Propylene sires industry's new hopefuls—derivatives, end-uses—Petrochemicals, Pt 4. Messing & Bradley (tables)....Sept. 5 60
Pure propylene feeds new resin industry—flowsheet....May 30 *78

Pulp and Paper
Bleach process—continuous controlled system improves bleach uniformity (chart) (N)....June 27 *64
Fiber board made from waste wood chips and sulfite liquor (N)..Aug. 8 62
For pulp and paper: new problems. R. A. Labine (charts)....Dec. 12 92
Inventory of new plants and facilities Apr. 18 180
Inventory of new processes and technology....May 2 115
Inventory—semiannual inventory of new plants and facilities....Oct. 17 179
Paper drying—new air-handling concept speeds drying (N)....June 13 *79
Process developments — Dorr-Oliver's HiFibre mechanical pulping process, using lime; and the Black Clawson low-power process (N)....Apr. 4 33
Sulfite pulping outlook brightens (N) (charts)....Apr. 18 96
Upflow pulping process at Hammermill may double design capacity (chart) (N)....Oct. 31 52

NOTES—(D.N.) Design Notebook; *Illustrated; (N) News; (P.N.) Plant Notebook

Pumps
Blowcase for pumping slag wool slurries. C. E. Billings & others (chart) (P.N.) ....Oct. 31 121
CE Cost File 33. Labor factors: Centrifugal pump systems. W. R. Kane June 13 232
Nomograph gives pump horsepower. Katell & Wellman (D.N.)...Dec. 12 176
Flow of fluids process design report—selecting centrifugal, other pumps. E. E. Ludwig (charts & tables) June 13 *185
Heat pump balances space heat in new facility (N) (chart).....Mar. 7 61
Priming a worn pump. M. Gluckman (P.N.) .....Nov. 28 *143
Quick way of finding net positive suction head (NPSH). M. Fridman (P.N.) .....Oct. 31 122
Standard near for horizontal centrifugal pumps .....Dec. 26 40
Purchasing—Purchasing process equipment. N. H. Parker. How do you evaluate the proposal? Pt III .....Jan. 25 111

R

Radiation
Gamma radiation gives plastics shape "memory" .....Aug. 22 80
Plastic scintillation fluors detect radiation .....Mar. 21 *106
Radiation processing for compounds (N) .....Jan. 25 52
Radioactivity
A-bomb fallout—filter plant removes fallout in river (N).....Mar. 7 *60
Desalting plant radiation hazards cancel Point Loma, Calif., site (N) June 13 82
Desalting plant regains Point Loma site by dropping plans for nuclear heat source (N).....July 11 78
Hazards—minimizing radiation hazards. L. J. Cherubin (tables).....June 27 *105
Lead-bonded metals shield radioactive corrosives (table) .....Nov. 14 *252
Radioisotopes—save agricultural dollars (N) .....Mar. 7 62
Railways
"Piggyback" railway transports first chemical-loaded tank trailer (N) July 11 80
Tank car can handle liquid HCl in bulk (N) .....Aug. 22 58
Rain Making
Cloud seeding no cure-all, California says (N) .....Sept. 19 96
Germany's dry summer may cause sticky politics (N).....Mar. 7 64
Reaction—Technique probes radical reactions (N) .....Feb. 8 70
Reactors see **Atomic Power, Design**
Record-keeping system—disposable copies of maintenance forms make record-keeping painless. T. W. Hudson Jan. 11 *134
Reduction—Iron—Orcarb's pelleting step promotes high prereduction of iron ore (N) .....June 27 *68
Refining
Copper—new layout streamlines copper refining at Kennecott—flowsheet Mar. 21 *134
Cracking catalyst—Grace's SM-30 replaces DA-5 (N).....July 25 66
Cracking catalysts boost yields..May 16 94
Moving beds unsnarl tricky reactions at Eldorado Mining & Refining, Ltd. (N) .....Jan. 11 *45
Salt refining automated at International Salt plant (chart) (N)..Oct. 31 *49
Trickle desulfurizing cleans up petroleum distillates—flowsheet Oct. 3 *76
Refractory Materials
Asbestosite refractory material stands 3,000 F. for hours.....Feb. 8 80
Ceramic brick .....Feb. 8 78
Metal crystals—arc-fusion process grows large refractory crystals (N)..July 25 *62
Promising extrusion of refractory metals Jan. 25 134
Refractory sheet developments—pace quickens (table) .....Nov. 14 256
Small grain size improves refractory metals .....Nov. 14 254
Titanium diboride, zirconium oxide reach new peaks in heat resistance Dec. 26 *62
Refrigeration
Recovery of LPG from natural gas boosted by refrigeration (chart) (N) Sept. 19 96
Salt water conversion by 2 refrigeration routes—flowsheet .....June 13 *152
Research
Chemical industry research called bad (N) .....July 25 66
Concrete—100-yr. test passes half-way mark (N) .....Oct. 17 94
Coordinated research urged (N) Nov. 28 76
Fuel-cell developments maintain fast pace (N) .....Oct. 31 54
Information problem—how to get through the wall of words. L. W. Ross .....Mar. 21 *143
Information retrieval—Better information retrieval—60's challenge report Jan. 11 100
Information retrieval—what will it do for the chemical engineer? J. W. Perry .....Dec. 26 88
Liquid hydrogen hardware gets evaluation tests (N).....Oct. 17 *94
Metals—research extends limits of "common" metals (N).....Mar. 21 84
Process industries up research spending Oct. 31 66
Read government research contracts carefully .....Oct. 31 66
R&D becomes an industry necessity—abstract from G. P. Giusti dissertation (chart & tables).....Apr. 4 78
Shock tube research. Victor Kevorkian (charts) .....Oct. 3 107
Soviet scientists trying to develop "chemistry information machine" (N) .....Feb. 8 62
Spectrometer probes core of nuclear particles (N) .....Sept. 5 52
Water-quality control sought to save fresh-water sources (N).....Oct. 17 *96
Westinghouse president reviews efforts to make basic research big, free, solvent .....May 2 74
Resin
ABS resin .....Jan. 11 62
Cellulose resin dissovles easily, is good thickener .....May 16 94
Cross-linked resins for nonwoven textile finishes .....June 13 98
Devlex resins for molecular complexing Oct. 3 *60
Epoxies, called Oxiron resins, cut process costs .....Mar. 7 *76
Epoxy family proliferates—peracetic acid is key.....Aug. 22 *78
Epoxy hardeners give flexibility, resilience .....May 2 78
Epoxy gives better high temperature service .....Mar. 7 80
Epoxy resins for field repair of leaking pipes .....Dec. 12 188
Epoxy shows up well as pipe coating May 16 96
Glass flakes in polyester resin make a strong coating (tables).....Sept. 5 *162
Inventory of new processes and technology .....May 2 115
Inventory of new plants and facilities Apr. 18 179
Inventory—semiannual inventory of new plants and facilities.....Oct. 17 178
Ion-exchange resin cleaner....Nov. 28 98
Ion-exchange resins become powerful process tool. Seamster & Wheaton (charts & tables).....Aug. 22 115
Isophthalic resin pipes.....Sept. 5 *74
Laminating resin solventless silicone July 25 78
Lexan—GE's polycarbonate resin Oct. 31 68
Making polycarbonates: a first look—GE's Mt. Vernon, Ind. plant—flowsheet .....Nov. 14 *174
Maraglas epoxy resin for transparent casting .....Dec. 12 *102
Merlon—Mobay's polycarbonate resin Apr. 18 *114
New process for stripping solvents from plastic resins (N).....May 30 52
Polyethylene resin for greaseproof coatings, heat seals.....Apr. 18 110
Phenolic resin combines favorably with rubber .....Mar. 21 104
Resin bonded quartz gives extra heat resistance .....Feb. 8 *80
Resins' stake in easy-care cotton July 25 *74
Waterproofing resin cuts paper mills' resin needs .....June 13 96
Rocket Propellants
Aerojet initiates first continuous propellant-making process (N)...May 2 *61
Binders for solid fuels.....Sept. 5-51, 76
Boron-fuel status changed (N)..Jan. 11 44
Encapsulating machine capable of high-speed output (N).....June 27 70
Hybrid rocket propulsion systems. Hendel & Cavecche (charts)..May 30 *93
Liquid H_2—new details round out the story (N) (chart).....Feb. 22 *61
Liquid hydrogen-neuclear-rocket work advances (N) .....June 27 72
Spherical metallic-bead powders, fuel additive .....Sept. 5 *72
Vinyl-based solid can be easily formulated and prepared.....June 27 86
Wire—from exploding wire, more thrust (N) .....Feb. 22 64
Rockets and Missiles
Atom-engine runs 15 minutes in successful test .....Dec. 26 40
Beryllium-oxide ceramics fast becoming a vital material.....July 11 *166
Bottom-casting technique loads rockets with solid-fuel (N) (chart)...Apr. 4 *74
Hybrid rocket propulsion systems. Hendel & Cavecche (charts)..May 30 *93
Plastic bests metal as rocket casing (N) Oct. 3 46
Recrystallized graphite approved for rocket nozzle inserts (N)....Nov. 14 114
Retro-rockets will soften landing of lunar instruments .....Oct. 17 *202
Rocket lag is biggest challenge—60's challenge report .....Jan. 11 97
Solid-fuel engine's conical shape has advantages (N) .....July 25 66
Rockets and Missiles see also **Space Technology**
Rubber
Asphalt rubberizing powders...Oct. 17 112
Butyl rubber carpet waterproofs. Humble building foundation..July 11 *86
Butyl rubber's new market pattern May 2 *70
Carbon black masterbatch takes off. Frances Arne (charts).....Oct. 3 54
European firms enter natural-synthetic rubber (N) .....Aug. 22 56
Fluorosilicone rubber immune to fuels and lubricants at high temperatures June 27 84
Inventory of new plants and facilities Apr. 18 181
Inventory of new processes and technology .....May 2 115
Inventory—semiannual inventory of new plants and facilities.....Oct. 17 179
Natural rubber modified to withstand low temperatures .....July 11 88
Phenolic resin combines favorably with rubber .....Mar. 21 104
Silicone rubber—GE's versatile process—flowsheet .....July 11 *102
Silicone rubber rapidly cures to solid form .....Oct. 17 114
Soviets order "ten-unit" synthetic rubber plant (N).....Jan. 11 44
Synthetic rubber—for high-quality, squeeze dry (N).....Aug. 8 *63
Tire treads perforated for better gripping .....Feb. 22 82
Tires—porky Terra-Tires' design spawns exotic vehicles .....Feb. 8 *82
Tree rubber's successors readied. Frances Arne (charts & table).....Sept. 19 104
Russia
Industrial output shows major boosts (N) .....Sept. 5 58
Moscow control conference—First Congress of International Federation of Automatic Control. Ernest Conine Sept. 19 *181
Moscow control conference—interview with David M. Boyd, Jr.....Sept. 19 *184
Plastics technology has become a top-priority R&D field (N).....Aug. 8 70
Aug. 22 64

S

Safety
Acetylene transmission system design—safety aspects (charts).....Sept. 5 *131
Be practical about safety. W. H. Richardson .....July 11 *156
Beware detonations.....Jan. 11 *105
Epoxides-via-peracetic-acid process gets ultimate safeguards (charts) (N) July 25 *68
Explosions rip chemical plants: Tennessee Eastman's aniline unit at Kingsport, Tenn.; Dow Chemical's Bay City complex; Allied Chemical's Buffalo, N. Y. plant (N).....Nov. 14 114
Plastic coating for lab glassware protects experimenters .....Apr. 18 *110
Pressure relief—how to design a system that safeguards your plant. Joseph Conison (charts).....July 25 *109
Radioactivity — minimizing radiation hazards. L. J. Cherubin (tables) June 27 *105
Safety lags behind new technology (N) Feb. 22 60
A safety program is a full-time job. Edward Allen.....Nov. 14 *246
Tanks—bad design causes blast-off Aug. 22 *160
Salt — Automated refining process on stream at International Salt's La. plant (chart) (N).....Oct. 31 *49
Seals
Alumina excels conventional potting compounds .....Jan. 25 *72
Liquid seal averts vent tank overpressure. Leonard Steber (P.N.) (chart) Apr. 18 198
Tank level gage rope sealed with inflated sleeve. W. E. Robertson (D.N.) (chart) .....May 30 111
Separation
Adsorption—Fixed-bed adsorption—report. H. M. Barry (charts & tables) Feb. 8 *105
Analyze absorption in gas separations—CE Refresher. Coates & Pressburg (charts) .....Oct. 3 99
Azeotropic and extractive distillation—report. Jesse Coates (charts & tables) May 16 *121
Balls replace dumbbells for separating products in Shell Oil's 250-mile pipeline (N).....Jan. 11 *45
CE Cost File 35. Centrifugal separators. J. C. Smith.....Sept. 5 148
Gas-sweetening — new absorbents cut H_2S removal cost (chart)....Dec. 26 44
Hydrogen from ammonia with small-volume Cryogenerator (chart) (N) Aug. 22 *54
Review heat transfer principles—CE Refresher. Coates & Pressburg How heat transfer occurs in evaporations (charts & tables)....Feb. 22 *139

NOTES—(D.N.) Design Notebook; *Illustrated; (N) News; (P.N.) Plant Notebook

Review principles of distillation—CE Refresher. Coates & Pressburg (charts) ....Nov. 28 137

Shipping
Liquid ethylene oxide may be shipped by truck (N)....Aug. 8 62
Liquid methane—Shell joins trans-oceanic shippers (N)....Mar. 7 70
Multiwall paper containers. T. E. Dowling (tables) Pt 1 May 16 *164, Pt 2 May 30 *116
Railway transports first chemical-loaded tank trailer (N)....July 11 80

Silica
Colloidal silica protects painted surfaces ....Mar. 21 104
Microfine silica offers new applications Sept. 19 110
Silica sol forms unusually strong bond (N). Feb. 22 82

Silicon—High-purity silicon yields single-crystal form....Sept. 19 *110

Silicones
"Raincoat" keeps masonry dry..Sept. 5 *76
Rubber—fluorosilicone rubber resists fuels and lubricants at high temperatures ....June 27 84
Rubber—GE's versatile silicone rubber process—flowsheet ....July 11 *102
Rubber—Silicone rubber rapidly cures to solid form....Oct. 17 114
Silicone-glycol aids cell structure of plastic foam....Mar. 7 *80
Silicones solve maintenance problems. B. P. Coe....Aug. 22 *156
Solution cuts cleanup time in shell molding ....Oct. 3 62
Solventless silicone in high temperature insulators ....July 25 78
Varnish—Ease of use marks new Class H varnish ....Jan. 25 *68

Solar Power—Solar energy, fuel cells slated to be teamed (N)....Feb. 8 62

Solid-solid blending—report. J. J. Fischer (charts) ....Aug. 8 *107

Solvents
Cold-cleaning solvent reclaimable by distillation ....June 13 *96
Fluor uses new solvent to lower gas-treating cost (chart) (N)....May 30 *46
High-boiling solvents make better surface coatings....Oct. 17 110
Hydrocarbon solvents removed from plastic resins by new process (N) May 30 52
Lactonitrile separate hydrocarbons Oct. 17 112

Space Technology
Engineers have key role in space May 30 110
Ethers—Bis (m-phenoxyphenyl) ether may lead field of high-temperature space fluids. Charles Spar....May 2 *77
Keeping men alive in space rockets. Humphrey & Deindoerfer (charts & tables) ....Apr. 18 *183
Nuclear reactors reach for the sky (N) May 16 84
Water for spacemen—GE tests supply technique (N)....July 25 62

Spying, Industrial—the truth about industrial spying. R. A. Labine..Feb. 22 *121

Stabilizers
Lecithin concentrate helps stabilize water-based paints....May 30 64
Stabilizer-dispersant cuts refinery fouling ....June 13 98
Ultraviolet stabilizers for vinyls, cellulosics, polyesters, polyolefins..Feb. 22 80

Standardization
Engineering-unit prefixes named (N) Feb. 8 62
Polyethylene pipe standards (N) May 2 60, Oct. 3 134
Pumps—standard near for horizontal centrifugal pumps ....Dec. 26 40
Standards help thwart rising costs—60's challenge report....Jan. 11 102
Welding — specification for covered electrodes issued by Navy....Oct 31 139

Starch
Dialdehyde starch made from corn using electrolytic cell (N)...Feb. 22 *64
Low B.O.D. starch improves weaving, cuts pollution....Oct. 31 70

Statistics
Cost statistics for the cost estimator. Gertz & Dennee....Oct. 31 *97
How statistics apply to chemical processes. T. L. Koehler....Dec. 12 142

Steam
Ammonia converter design modified for steam generation (chart) (N) Aug. 22 60
Prospects for nuclear process heat. Wright & Smith....Nov. 28 *123
Rx for better steam economy: condensate return systems. R. J. Lundrigan (chart & table)....Oct. 3 121
Steel process using steam ups Soviet output (N)....Mar. 21 82

Steel
Alloy steels for low-temperature construction. Rote & Proctor....June 27 *119
Austenitic stainless steels for low temperature construction. McConnell & Brady (tables) ....July 11 *125
Carbon steel—new, lighter, stronger, structural steel....Sept. 19 220
Carbon steels for low-temperature construction. R. W. Vanderbeck..May 30 *103
High-temperature alloy for 1,650F Nov. 28 164
Open-coil process produces better steel sheet for less (N)....Aug. 22 *58
Oxygen keeps steel in turmoil—latest area of attack—the blast furnace (N) Nov. 28 *77
Polyethylene noses out steel for gas pipeline (table) ....May 30 124
Stainless—stronger cast stainless alloy keeps promises. E. A. Schoefer (tables) ....Mar. 7 164
Steam used instead of oxygen ups Soviet output (N)....Mar. 21 82
"Super-weldable" stainless coming Aug. 22 162
Tankers: stainless to plastic gamut Jan. 25 *130
Tougher steels for process equipment (N) ....Oct. 31 54
200 steel experts for metal show staff Oct. 17 220

Storage—Cavern to store liquified propane Dec. 26 *40

Sugar
Imperial's refinery adds melt house designed for automatic flow—flowsheet May 2 *94
Shakeup brewing in sugar processing (N) ....Dec. 12 82

Sulfur
Haines recovery process goes into pilot plant (N)....Dec. 12 *86
Nuclear mining could lower sulfur cost (N) ....June 27 66
Poland's sulfur program may upset world markets (N)....Dec. 12 78
Supply and demand outlook to 1970 (tables) ....Aug. 8 74

Sulfuric-acid
Converting waste sludge acids to H_2SO_4 at Dixon Chemical—flowsheet Jan. 11 *80
Corrosion data for sulfuric-resisting alloys. Schillmoller & LaQue (chart & table) ....Apr. 4 170
Dialysis breaks acid-recovery barrier at Phelps-Dodge (N) (table)....May 2 *64
H_2SO_4: old dog, new tricks. D. B. Burkhardt (tables)....Dec. 26 99
"Vac" evaporator cut costs of waste acid recovery (N)....Aug. 8 *66

Surfactant—Nonionic surfactant remains stable at 50 C....Jan. 11 60

T

Tanks
Blast-off due to bad design....Aug. 22 *160
Brick-lined process equipment. Donald Thompson (charts & table) Pt 1 Feb. 22 *129, Pt 2 Mar. 21 *161
CE Cost File see under **CE Cost File**
Corrosion-control design see under **Corrosion**
Easy way to stop discharge vortexing. R. D. Connolly (P.N.)....Sept. 5 154
Nomographs help find tank diameter. Leon Green (D.N.)....Feb. 8, 143, Correction ....Apr. 18 198
Railway tank car can handle liquid HCl in bulk (N)....Aug. 22 58
Storage tanks made of large-diameter, prestressed concrete pipe....July 11 *164
Storage tanks of reinforced plastic better than steel (table)....Apr. 18 *214
Submersible rubber storage tanks piloted (N)....June 13 88
Vinyl sheet blocks seepage through concrete foundations (N)....Oct. 31 *54

Tantalum
Bids for bigger use in process equipment (N)....Feb. 22 70
Low-temperature service touted May 30 126

Tar — Dual-solvent extraction process being piloted at Texas plant may set tar's future (N) (chart)....Apr. 4 *70

Molding — controlled squeezing molds polytetrafluoroethylene ....Dec. 26 46

Teflon
Cementable Teflon ....Nov. 28 96
Lubricant is aerosol-applied....Oct. 17 114
Monofilament fiber may move in on noble metals ....Dec. 26 62

Temperature
Ceramic-coated metals handle much higher temperatures than glassed steel (charts & table)....Oct. 3 130
Chart for compression and expansion temperatures. C. A. Kleppe (D.N.) Sept. 19 213
Highest temperatures await containment—60's challenge report...Jan. 11 96
Low-temperature construction materials (charts & tables)
Carbon steels. R. W. Vanderbeck May 30 *103
Alloy steels. Rote & Proctor..June 27 *119
Stainless Steel. McConnell & Brady July 11 *125
Nickel steel alloys. R. J. Johnson July 25 *115
Aluminum alloys. E. W. Johnson Aug. 8 *133
Copper and its alloys. C. L. Bulow Sept. 19 *187
Low-temperature metals: a roundup. G. H. Zenner....Oct. 31 *117
Pressure vessel design for high or cryogenic temperatures. R. R Maccary (charts) ....Nov. 28 *131
Rubber modified to take low temperatures without hardening....July 11 88
Shock-tube research of high-temperature gas-phase reactions. Victor Kevorkian (charts)....Oct. 3 107
Tantalum touted for low-temperature service ....May 30 126
Temperature checkup shows which valves leak. K. H. Parekh (P.N.) Nov. 28 144

Tetramethyl Lead—Use and production of TML stepping up (N)....July 11 78

Textiles
Cationic agent softens fabrics, intensifies color....Nov. 28 98
Cotton—resins' stake in easy-care cotton ....July 25 *74
Cross-linked resins promise nonwovens quality finishes....June 13 98
Nonionic liquids aid in textiles manufacture ....Dec. 26 63
Nonwovens, using paper technology, look toward major textile markets (chart & table)....Apr. 18 *104
Starch—low B.O.D. starch improves weaving, cuts pollution....Oct. 31 70
Warp filament size increases weaving efficiency ....Nov. 28 98

Thermodynamics
"Atomized suspension technique" (AST) replacing bacterial digestion for treatment of municipal sewage sludge in Quebec (N)....Jan. 25 *56
11 quick tests for data consistency. B. C-Y. Lu....Oct. 3 *105
How to predict ternary azeotropes. Imrich Klein ....Nov. 14 233
Pressure-enthalpy plot for Dowtherm A. Frank Maslan (D.N.)....July 25 *146
Process kinetics can predict reaction mechanism. Henry Eyring (tables) Dec. 26 83
Pump balances space heat in new facility (N) (chart)....Mar. 7 61
Unsteady-state heat transfer. Davis & Akers see under **Heat Transfer**

Titanium
How will titanium fare in 1960? (N) Feb. 22 66
Tubing makes good in hypochlorite plant ....May 30 *126
Titanium diboride powder for fabricating process equipment ....Dec. 26 *62
Toluene—Oil-based aromatics gain first place. Messing & Bradley (tables) Dec. 26 50
Training—Staffing new plants for start-ups. J. H. Riddle....Oct. 31 *126
Transportation—Coker moves 325 miles in record lift (N)....Apr. 18 *100

Trona
New mining system to get tryout (N) June 27 70
Stauffer's trona plans meet new blocks (N) ....May 2 60

Tubing
CE Cost File 28: Welded and seamless heat exchanger tubing....Apr. 4 156
Finned tubes can save money under fouling conditions. W. O. Webber (table) ....Mar. 21 *149
Flow of fluids process design—report. E. E. Ludwig (charts & tables) June 13 *161
Titanium makes good in hypochlorite plant ....May 30 *126
Vanadium—tubing made from ductile vanadium (N)....Jan. 25 52
Welded tubes — new manufacturing methods combat old prejudices. E. W. Allardt (tables)....Apr. 4 *135

U

Ultraviolet absorber light-stabilizes polyolefin plastics....June 27 82

Unit Operations
Absorption with chemical reaction—report. A. J. Teller (charts & tables) July 11 *111
Adsorption—Fixed-bed adsorption—report. H. M. Barry (charts & tables) Feb. 8 *105
Better use for control charts. E. S. Aldredge ....Jan. 25 *95
H_2SO_4: old dog, new tricks. D. B. Burkhardt (tables) ....Dec. 26 99

V

Vacuum
Check for vacuum producers. E. F Harp (P.N.) ....May 16 *162
Leak-proof joint for high vacuum work. V. N. Schrodt (D.N.)....Jan. 11 *128

Valves
Corrosion-control design. E. G. Holmberg
4a Valve design: special for corrosives ....June 13 *238
4b Valves for severe corrosive service June 27 *146
Emergency repair for an oleum outlet valve. A. J. Stewart (P.N.)...July 11 154

Four-way valves provide foolproof piping system. D. E. Milholland (P.N.) Oct. 3 *117
Pressure relief—how to design a pressure relief system. Joseph Conison (charts) ....July 25 *109
Temperature checkup shows which valves leak. K. H Parekh (P.N.) Nov. 28 144
Varnishes—Ease of use marks new Class H varnish....Jan. 25 *68
Vinyl
Geon, new vinyl, may move in on metals ....June 27 *82
Plastic lining retains city reservoir's water ....Oct. 17 *110
PVC stabilizers help vinyl processing Apr. 4 90
Rocket propellant vinyl-based solid June 27 86
Two winners, no losers in plastics record ....Feb. 22 60
Vinyl sheet blocks seepage through tank foundations (N)....Oct. 31 *54
Vinyl Chloride—Ethylene copes with competition—capacity, outlook, end-uses. Messing & Bradley (table)...Aug. 22 70

W

Warehouses—CE Cost File 25 and 26 Unit construction costs. A. R. Sellers. .Feb. 22, 151, Mar. 7 152
Waste Disposal
Atomic waste disposal by foaming backed by AEC (N)....Aug. 8 68
"Atomized suspension technique (AST) replacing bacterial digestion for treatment of municipal sewage sludge in Quebec (N)....Jan. 25 *56
Chemicals for waste neutralization compared (chart)....May 30 92
Incinerator cuts cost of atom-waste disposal (N)....Aug. 22 *56
Knowing your chemicals saves money in waste treatment. H. L. Jacobs (charts) ....May 30 *87
Mercury cell process regenerates waste pickle liquor acid, recovers iron (N) (chart) ....May 16 82
Pickle liquor process uses "vac" evaporator to cut acid recovery costs (N) Aug. 8 *66
Space travel—keeping manned rockets free of toxic wastes. Humphrey & Deindorfer (charts & tables)..Apr. 18 *183
Sulfite-waste liquor report recommends limits in water over oyster beds (N) May 30 50
Washington tightens up pollution control laws (N)....Dec. 12 78
Zimmermann process consumes sludge by flameless combustion (N)..Nov. 28 *80
Water
Evaporation factors studied (N) June 13 88
Heavy water
British process shaves costs (charts) (N) ....Sept. 19 92
Deuterium Corp. to start first private production (N) ....Oct. 17 94
Hydrogen distillation for heavy-water on stream in France (N)...Mar. 21 *92
Industrial water scarce by 1980? (N) Aug. 8 62
Salt-water cooling woes—corrosion control ....Aug. 22 164
Water Pollution
A-bomb fallout—filter plant removes fallout in river (N)....Mar. 7 *60
Oyster growers demand stiffer pollution laws (N) ....Oct. 3 52
Pollution control cost is growing—60's challenge report....Jan. 11 103
Public Health Service schedules national conference on water pollution (N) ....Sept. 5 58
Sulfite waste-liquor — report recommends limits in oyster growing areas (N) ....May 30 50
Water-quality control sought to save fresh-water sources (A)....Oct. 17 *96
Water Supply
Air-cooled heat exchanger solves fresh-water problem (N)....Oct. 3 *44
Desalting plants—rundown on processes for government's 5 demonstration plants (table)....July 25 *105
Fight to save water quickens (N) Oct. 17 *96
Industrial water scarce by 1980? (N) Aug. 8 62
Water-quality control sought to save fresh-water sources (N)....Oct. 17 *96
Water Treatment
Desalting—5 major processes for government's 5 demonstration plants (table) ....July 25 *105
Desalting plant radiation hazards cancel Point Loma, Calif., site...June 13 82
Desalting plant regains Point Loma site by dropping plans for nuclear heat source (N)....July 11 78
Desalting plants — government's fifth demonstration plant will use a freezing process (N)....Apr. 4 65
Evaporation cut by new device for spreading cetyl alcohol (N)..Mar. 7 68
Flocculant for treatment of potable water ....Mar. 21 102
Salt water conversion by 2 refrigeration routes—flowsheet ....June 13 *152
Sea water—giant still slated for Caribbean (N)....Mar. 21 94
Wax
Decolorizing of liquid wax improved by continuous operation (N) (chart) Mar. 21 90
DX Sunray Oil's solvent dewaxing plant design (N)....Nov. 14 *118
Synthetic wax boosts melting point of other waxes....Nov. 14 138
Welding
CE Cost File 28: Welded and seamless heat exchanger tubing....Apr. 4 156
Nylon-to-metal chemical welding Oct. 3 64
Specification for covered electrodes issued by Navy....Oct. 31 139
Steel—"super-weldable" stainless coming ....Aug. 22 162
Superfluidity: key to plating, welding routes? (N)....Jan. 25 52
Thermosetting structural adhesive for aircraft parts welding....Nov. 14 *136
Tubing — new manufacturing methods combat old prejudices. E. W. Allardt (tables) ....Apr. 4 *135
Wood
Canada's waste wood to move in plastic spheres (N)....Jan. 11 50
Hardboard plant uses unique version of dry process—flowsheet ....Dec. 26 74
Waste chips and sulfite liquor used to make fiber board (N)....Aug. 8 62

Z

Zinc oxide—use shifts in rubber, paint markets ....May 30 60
Zirconium—Higher purity boosts zirconium resistance. W. E. Kuhn (chart & tables) ....Feb. 8 *154
Zirconium oxide sponge withstands 4,200 F. ....Dec. 26 *62

NOTES—(D.N.) Design Notebook; *Illustrated; (N) News; (P.N.) Plant Notebook

AUTHOR INDEX

Ackley, Edward J.
Film coefficient of heat transfer for agitated process vessels....Aug. 22 *133
Adams, Charles A.
Construction equipment rental rates Feb. 8 146
Akers, W. W. and S. H. Davis, Jr.
Unsteady-state heat transfer Pt 1 Apr. 18 *187, Pt 2....May 16 *151
Aldredge, Edmond S.
Better use for control charts...Jan. 25 *95
Aldrich, Charles K.
Corrosion-control design—tanks July 25 *148 ....Aug. 8 *154
Selecting materials for process piping Nov. 14 *183
Allardt, Ernest W.
Welded tubes slash equipment cost Apr. 4 *135
Allen, Donald R.
Electrochemical fluorinator uses porous carbon anode....Sept. 19 *216
Allen, Edward
A safety program is a full-time job Nov. 14 *246
Allen, Merton
Fluorescent particles for tracing liquid flow ....June 27 136
Anderson, T. H.
Curing troubles with a long gage glass Mar. 21 168
Arne, Frances
Carbon black masterbatch takes off Oct. 3 54
Chemical lubes measure up....Jan. 25 *62
Tree rubber's successors readied Sept. 19 104
Arnold, T. H. Jr. & N. P. Chopey
New ideas refresh alumina process Nov. 28 *108
Avery, C. E., Jr. & C. W. Boyer
Screens improve filter performance June 13 *226
Bacon, John B.
Industrial gases ride technology boom Jan. 11 *54
Oil: the squeeze comes in the '60's Mar. 21 96
Bagnard, C. M.
Use swivel joints for flexibility..Sept. 19 *175
Barry, H. M.
Fixed-bed adsorption....Feb. 8 *105
Bass, Max S.
Designing reactors for operation July 25 *125
Multiple-pitch screw equalizes discharge ....Jan. 11 *126
Bates, Robert L.
Guide to industrial viscometry..Apr. 4 145
Bechtel, Louis R.
Estimate working capital needs Feb. 22 127
Berk, J. M. & J. E. Haselbarth
Analysis of ethylene plant costs Apr. 18 194
Chemical plant cost breakdown May 16 158
Cost-capacity data ....Dec. 12 172
Engineering valuation...Nov. 14 244, Nov. 28 146
Bernard, John W.
Estimating process instrumentation Jan. 25 120
Berry, Richard M.
Estimate manufacturing costs..June 27 *123
Billings, C. E. & others
Blowcase for slurries takes on modern guise ....Oct. 31 *121
Billitzer, A. W.
For batching use hydraulic paradox Jan. 25 122
Bohl, Alfred J.
Improve small plant materials control Apr. 18 *206
Boyer, C. W. & C. E. Avery, Jr.
Screens improve filter performance June 13 *226
Bradley, J. W. & R. F. Messing
Oil-based aromatics gain first place Dec. 26 50
Petrochemicals
Pt 1—May 30-54, Pt 2—June 27-74, Pt 3—Aug. 22-66, Pt 4....Sept. 5 60
Brady, R. R. & J. H. McConnell
Austenitic stainless steels....July 11 *125
Brennan, Peter J.
The operating man....Sept. 5 *156
Brice, L. D.
Twin orifices proportion liquid to gas flow ....Jan. 11 *130
Brosnan, Donald F.
Estimating engineering drafting costs May 30 114
Browder, T. J.
Shell-side heat-transfer coefficient Oct. 17 207
Bulow, C. Lawrence
Copper and its alloys for low temperature versatility....Sept. 19 *187
Bunn, Howard S.
The management function of the engineer in industry....Nov. 14 *239
Burkhardt, D. B.
H_2SO_4: old dog, new tricks....Dec. 26 99
Burnett, J. W. & J. P. Kinney
Colorimeters watch for wrong connections ....Mar. 21 *167
Butler, F. A. & R. B. Nippe
Flowmeter is maintenance-free..Feb. 22 *154
Caplan, F.
Nomograph for excess air....Oct. 31 *122
Carp, J. R. & C. E. Drake
Shell-and-tube heat exchangers Apr. 18 *165
Carstens, Ron
Graph shows plant economics...May 2 *138
Cavecche, E. H. & F. J. Hendel
Consider hybrid propulsion systems May 30 *93
Cherubin, L. J.
Minimizing radiation hazards..June 27 *105
Chopey, N. P. & T. H. Arnold, Jr.
New ideas refresh alumina process Nov. 28 *108
Clayton, J. W.
Budgeting maintenance costs...Feb. 22 *156
Coates, Jesse
Azeotropic separations ....May 16 *121
Coates, Jesse & B. S. Pressburg
CE Refresher: Review heat transfer principles
Match heat transfer principles to your exchanger needs....Jan. 25 *101
How heat transfer occurs in evaporations ....Feb. 22 *139
Multiple-effect evaporators...Mar. 21 *157
CE Refresher: Review mass transfer concepts ....Sept. 5 135
Analyze absorption in gas separations ....Oct. 3 99
How to design packed-tower adsorbers ....Oct. 31 109
CE Refresher: Review principles of distillation ....Nov. 28 137

Coe, Benjamin P.
Silicones solve problems.....Aug. 22 *156
Collins, G. F. & R. T. Mathews
Improving air-cooler design....May 16 *137
Conine, Ernest
Moscow control conference.....Sept. 19 *181
Conison, Joseph
How to design a pressure relief system
July 25 *109
Connolly, Richard D.
Easy way to stop discharge vortexing
Sept. 5 154
Conway, Joseph B.
Find flashback velocity at high pressure
May 2 *140
Crom, W. H. & H. B. Lange
Consider a job in technical service
Aug. 22 142
Davis, Sam H., Jr.
Unsteady-state heat transfer Pt 3 June 13-213, Pt 4 July 11-135, Pt 5..Aug. 8 *137
Davis, S. H., Jr. & W. W. Akers
Unsteady-state heat transfer Pt 1 Apr. 18 *187, Pt 2.....May 16 *151
Dawson, John E.
Corrosion-control design—reactors
May 2 *150, May 16 *170
Deindoerfer, F. H. & A. E. Humphrey
Keeping men alive in space rockets
Apr. 18 *183
Dennee, R. F. & S. A. Gertz
Statistics for the cost estimator
Oct. 31 *97
Dowling, Thomas E.
Containers for chemicals.....Oct. 3 *85
Multiwall paper containers Pt 1 May 16-*164, Pt 2.....May 30 *116
Drake, C. E. & J. R. Carp
Shell-and-tube heat exchangers
Apr. 18 *165
Dryden, C. E. & F. C. Vilbrandt
Process control instrumentation
Jan. 11 124
Erikson, Arthur
Chemical engineer turned diplomat
May 30 *107
Eyring, Henry
Process kinetics can predict reaction mechanism .....Dec. 26 83
Fahnoe, Frederick
Interface control using thermistors
Feb. 22 153
Farkas, Adalbert & M. H. Ziv
Heated arm simplifies solids distillation problem .....Mar. 7 *158
Feichtinger, C. A.
New idea in jacketed vessels....Sept. 5 *127
Fischer, John J.
Solid-solid blending .....Aug. 8 *107
Frenied, Raymond F.
Get your next job the new, easy way
Nov.28 *154
Profile of a propulsion proposal team
Oct. 17 *138
What basis for comparing salaries?
Oct. 3 125
Fridman, M.
Quick way of finding net positive suction head.....Oct. 31 122
Friedman, S. H. & J. W. Murtha
Process design of a distillation reflux drum .....Nov. 14 235
Friend, Leo & others
New data on entrainment from perforated trays at close spacings
Oct. 31 101
Fulton, George P.
Control storm and flood water...May 2 129
Gambill, Wallace R.
How to estimate engineering properties
Jan. 11 109
Gaudlitz, Robert T.
Corrosive-acids heater.....Sept. 19 *214
Gertz, S. A. & R. F. Dennee
Statistics for the cost estimator
Oct. 31 *97
Gibbons, E. J.
Home-made hygrometer .....Nov. 28 *144
Giladi, J.
"Sniffer" locates leaks.....Oct. 3 *118
Giladi, J. & S. Sideman
Water flow controls time-delay relay
Aug. 8 *145
Gillett, Fred L.
Choosing drivers for centrifugal compressors .....Mar. 7 143
Gluckman, M.
Priming a worn pump.....Nov. 28 *143
Gray, Albert W.
Do you have a permanent job? Really?
Sept. 5 *142
You must deliver competency and skill
Mar. 21 *169
Green, Leon
Nomographs help find tank diameter
Feb. 8 143
Gross, Sidney
Gas flow calibration correction..Aug. 22 *154
Gunkler, A. A. & D. E. Lake
Moisture: key to bromine corrosion
Oct. 31 *136
Hackney, John W.
Capital cost estimates for process industries Pt 1 Mar. 7 113-130, Pt 2
Apr. 4 *119-134
Hall, C. R.
Can computers control your process?
Mar. 21 *153
Harp, E. F.
Check for vacuum producers...May 16 162
Hartsook, Edmund A.
Are we meeting the union challenge?
Feb. 22 145
Haselbarth, J. E. & J. M. Berk
Analysis of ethylene plant costs
Apr. 18 194
Chemical plant cost breakdown
May 16 158
Cost-capacity data .....Dec. 12 172
Engineering valuation....Nov. 14-244, Nov. 28 146
Hauser, Paul & E. J. Mikity
Chamber-of-Commerce chemical engineer .....Apr. 18 *201
Head, G. L.
Transparent nomogram is handy for operation .....June 13 236
Hegeman, George
Plastics make a dent in paper markets
May 16 88
Heinmiller, Paul R.
How to write a good technical article
May 2 *127
Hendel, F. J. & E. H. Cavecche
Consider hybrid propulsion systems
May 30 *93
Holmberg, Emil G.
Corrosion-control design—valves
June 13 *238, June 27 *146
Horvath, Paul J.
"Hypodermic still" provides source of vapor-liquid data.....July 25 *142
Howland, H. F. & Lawrence Lynn
Use capital ratio.....Feb. 8 131
Hudrlik, Roger E.
Thermistor level control works in difficult service .....May 16 160
Hudson, T. W.
Disposable copies of maintenance forms make record-keeping painless
Jan. 11 *134
Humphrey, A. E. & F. H. Deindoerfer
Keeping men alive in space rockets
Apr. 13 *183
Hunter, J. S.
Optimize your chemical process with evolutionary operations.....Sept. 19 193
Hutton, J. L.
Plate-and-frame filters.....July 25 132
Hyman, S. C. & G. E. White
Constant rate filtration scaleup
June 13 *219
Jacobs, H. L.
Know your chemicals, save money
May 30 *87
James, G. Russell
Which process best for producing hydrogen? .....Dec. 12 *161
Janchen, Dieter
Activated alumina for gas drying
Oct. 31 115
Johnson, Edsel W.
Aluminum alloys .....Aug. 8 *133
Johnson, R. J.
Nickel steel alloys.....July 25 *115
Jones, Sam A.
Roll feeder controls solids flow..Aug. 22 *150
Kane, William R.
Centrifugal pump systems.....June 13 232
Katell, S. & P. Wellman
Nomograph gives pump horsepower
Dec. 12 176
Ketner, S. E.
Minimize batch equipment cost
Aug. 22 121
Kevorkian, Victor
Chemical shock-tube research...Oct. 3 *107
King, John A.
U. S. ammonia feels foreign impact
July 11 *82
Kinney, J. P. & J. W. Burnett
Colorimeters watch for wrong connection .....Mar. 21 *167
Kirkpatrick, Sidney D.
The New Chemical Engineering
Dec. 12 141
Klein, Imrich
How to predict ternary azeotropes
Nov. 14 233
Klengen, J.
Some rules of thumb for quick estimations .....Mar. 7 156
Kleppe, Carl A.
Chart for compression and expansion temperatures .....Sept. 19 213
Koehler, T. L.
How statistics apply to chemical processes .....Dec. 12 142
Kovacs, Jules P.
A new guide to filter media....June 13 *209
Kowalczyk, Leon S.
Why not one expression for the rate of reaction?.....Oct. 17 *191
Kroeger, Herbert E.
Use discounted cash-flow method
May 16 143
Kuhn, W. E.
Higher purity boosts zirconium resistance .....Feb. 8 *154
Kuong, Javier F.
Chart finds heat loss rate.....July 25 *146
Sum-of-years depreciation.....Nov. 14 236
Labine, Roland A.
For pulp and paper: new problems
Dec. 12 92
The truth about industrial spying
Feb. 22 *121
Lake, D. E. & A. A. Gunkler
Moisture: key to bromine corrosion
Oct. 31 *136
Lange, H. B & W. H. Crom
Consider a job in technical service
Aug. 22 142
LaQue, F. L & C. M. Schillmoller
New look at sulfuric-resisting alloys
Apr. 4 *170
Lee, Chesman A.
How to size conduits for storm sewers
Oct. 3 97
Lemieux, Elzear J. & others
New data on entrainment from perforated trays at close spacings
Oct. 31 101
Lemlich, Robert
Test your CEQ..Oct. 17-207, Nov. 14-236 .....Dec. 12 178
Leonard, Robert E.
Breakproof gage glass of plastic in a metal tube .....Nov. 28 *143
"Quickie" sightglass for pilot plant reactor .....June 27 *138
Levenbaum, Lester & others
Blowcase for slurries takes on modern guise .....Oct. 31 *121
Loretta, Frank B.
Chemical men look south of the border
Feb. 8 74
Mexican chemicals thrive.....Feb. 22 76
Loy, Tom & R. R. Palumbo
Save time with gas-law nomograph
May 30 *112
Lu, Benjamin C.-Y.
11 quick tests for data consistency
Oct. 3 *105
Ludwig, Ernest E.
For process design: flow of fluids
June 13 *161
Ludwig, E. E. & D. L. Whitley
Find effective length of U-tubes.June 27 *111
Lundrigan, Ralph J.
Rx for better steam economy: condensate return systems.....Oct. 3 *121
Lynn, Lawrence & R. F. Howland
Use capital ratio.....Feb. 8 131
MacBeth, Gordon
Slurry feeder for pilot plants....Mar. 7 154
Maccary, Raymond R.
How to select pressure-vessel size
Oct. 17 187
Pressure vessel design for high or cryogenic temperatures.....Nov. 28 131
Marine, Gordon
Process variables by chart.....Dec. 26 *108
Maslan, Frank
Pressure-enthalpy plot for Dowtherm A
July 25 *146
Mathews, R. T. & G. F. Collins
Improving air-cooler design....May 16 *137
Mathewson, W. F., Jr. & J. C. Smith
Flowmeter depends on variable weight
May 2 *136
Mayer, J. W. & Paul Taylor
Scientific inventory control.....June 27 *140
Mayling, A. A.
Air lift operates from syphon..Aug. 22 *152
Laboratory solvent extractor...Jan. 11 *128
McConnell, J. H. & R. R. Brady
Austenitic stainless steels.....July 11 *126
Mears, Robert B.
Plant site, layout minimize corrosion
Jan. 11 *144
Measing, R. F. & J. W. Bradley
Oil-based aromatics gain first place
Dec. 26 50
Petrochemicals
Pt 1—May 30-54, Pt 2—June 27-74, Pt 3—Aug. 22-66, Pt 4.....Sept. 5 60
Michel, E. Wayne
CE Cost File Labor factors May 2-142, June 27-134, Aug. 22-148....Sept. 19 208
Mikity, E. J. & Paul Hauser
Chamber-of-Commerce chemical engineer .....Apr. 18 *201
Milholland, Dick E.
Four-way valves provide foolproof piping system.....Oct. 3 *117
Miller, Thomas W.
Steam cuts NO content of inert gases
June 13 *234
Mills, Herbert E.
Estimating bucket elevator costs
Nov. 28 *117
Moore, Robert W.
Repair filter leaves by fabric "welding"
Aug. 8 146
Y-Splitter improves gassing of samples .....June 13 236
Moss, Richard Y.
Think of weighing for process control
Aug. 8 *147
Murphy, Lawrence
The next talk you have to give..Apr. 4 *151
Murtha, J. W. & S. H. Friedman
Process design of a distillation reflux drum .....Nov. 14 235
Nippe, R. B. & F. A. Butler
Flowmeter is maintenance-free.Feb. 22 *154
Palumbo, R. R. & Tom Loy
Save time with gas-law nomograph
May 30 *112
Parekh, Kishor H.
Temperature checkup shows which valves leak.....Nov. 28 144
Parker, Norman H.
Corrosion-control design
Guides to reducing agitator failures
Dec. 12 *190
Fabrication: key to mixer corrosion
Dec. 26 *112
How do you evaluate the proposal?
Jan. 25 111

Peiser, A. M.
Better computer solution of multi-component system.....July 11 *129
Perry, James W.
'information retrieval.....Dec. 26 88
Petruzzi, Daniel J.
What makes Henry talk?.....May 16 *147
Parker, Norman H.
Powell, Robert G.
How to start out on the right foot Sept. 19 *209
Price, Frederick C.
Cement outlook: grim but hopeful Oct. 31 *60
Pressburg, B. S. & Jesse Coates
CE Refresher: Review heat transfer principles
Match heat transfer principles to your exchanger needs.....Jan. 25 *101
How heat transfer occurs in evaporations .....Feb. 22 *139
Multiple-effect evaporators..Mar. 21 *157
CE Refresher: Review mass transfer concepts .....Sept. 5 135
Analyze absorption in gas separations .....Oct. 3 99
How to design packed-tower absorbers .....Oct. 31 109
CE Refresher. Review principles of distillation .....Nov. 28 137
Proctor, J. H. & Richard Rote
A-300 alloy steels.....June 27 *119
Ramsey, Stewart
If your company gets into politics Jan. 25 118
Reilly, A. J.
Estimating pressure vessels....July 11 146
Reinhold, Herman F., Jr.
Extending data with existing charts Apr. 4 162
Reul, Raymond I.
Measuring and controlling costs Sept. 19 203
Richardson, Wingate H.
Be kind to salesmen.....May 2 *144
Be practical about safety.....July 11 *156
Don't accept specification headaches Feb. 8 *148
Stealing: what can you do about it? Oct. 17 *210
Riddle, Jack H.
Some thoughts on staffing new plants Oct. 31 *126
Roberts, C. F. A.
Constant rate lab feeder.....Dec. 26 107
Use template to speed repetitive calculations .....June 27 *136
Robertson, W. E.
Inflated sleeve seals tank gage rope May 30 111
Roche, Thomas J.
Where estimators go wrong...Aug. 22 125
Rodrigues, Ferdinand
Short-cut to equilibrium plots...Mar. 7 *156
Ross, Laurence W.
The information problem.....Mar. 21 *143
Rote, Richard & J. H. Proctor
A-300 alloy steels.....June 27 *119
Roth, Jesse
Slide-rule solutions for cubic equations .....Jan. 11 130
Rubin, Frank L.
Design of air-cooled heat exchangers Oct. 31 *91
Scheirman, William L.
Better way to read emergency delta P's .....June 13 236
Schenk, Harry M.
Reduce costly down time.....Apr. 4 *164
Schillmoller, C. M. & F. L. LaQue
New look at sulfuric-resisting alloys Apr. 4 *170
Schley, John R.
New surfacing methods vie with old Mar. 21 *184
Schoefer, E. A.
Stronger cast stainless keeps promises Mar. 7 164
Schreiner, W. C. & others
New data on entrainment from perforated trays at close spacings Oct. 31 101
Schrodt, V. N.
Leak-proof joint for high vacuum Jan. 11 *128
Schultz, Richard S.
Score your executive attributes.Oct. 31 131
Schustek, George W. Jr.
How to house process development Feb. 8 *127
Schwartz, M. S.
Pilot steam generator boasts control Apr. 4 158
Seamster, A. H. & R. M. Wheaton
Ion exchange becomes powerful processing tool .....Aug. 22 *115
Schweyer, H. C.
Chart speeds calculation of economic batch size .....Sept. 5 152
Seiner, Jerome A.
Chart finds volume or density..Mar. 7 158
Sellers, A. R.
Warehouses: unit costs Feb. 22-151, Mar. 7 152
Sheets, Thomas M.
Temporary dust collector saves two months' time.....Oct. 31 *122
Sherman, Arthur T.
Rate instruments for maintenance Mar. 21 178
Shulman, W.
Vapor pressure of organics.....Dec. 12 180
Sideman, S. & J. Giladi
Water flow controls time-delay relay Aug. 8 *145
Silverman, Leslie & others
Blowcase for slurries takes on modern guise .....Oct. 31 *121
Smith, D. R. & J. H. Wright
The prospects for nuclear process heat Nov. 28 *123
Smith, J. C.
Centrifugal separators.....Sept. 5 148
Smith, J. C. & W. F. Mathewson, Jr.
Flowmeter depends on variable weight May 2 *136
Smith, J. X. F.
Emergency repair for an oleum outlet valve .....July 11 154
Smith, R. L.
Automatic switch for cooling water Apr. 18 *196
Spangler, C. D. & S. M. Walas
Process equipment nomograph..Mar. 21 173
Spar, Charles
Bis (m-phenoxyphenyl) ether..May 2 *77
Steber, Leonard
Liquid seal will prevent overpressure Apr. 18 *198
Steinfeld, R. C.
Critical path saves time and money Nov. 28 *148
Stewart, A. J.
Simple chain scraper for dry dust collectors .....July 11 *154
Sylvester, W. A.
Beware of the expert speech makers Aug. 8 142
Tao, Luh C.
Interpreting dimensionless groups Nov. 28 129
Taylor, Paul & J. W. Mayer
Scientific inventory control....June 27 *140
Teller, Aaron J.
Absorption with chemical reaction July 11 *111
Tendulkar, M. S.
Falling-film evaporator.....Oct. 17 *208
Thomas, Burton L.
How to calculate heat, water losses Aug. 8 *129
Thompson, Donald
Brick-lined process equipment
How to select and design....Feb. 22 *135
Designing details.....Mar. 21 *161
Timmons, H. L.
Scheduling keeps costs in line..Mar. 7 *160
Tipton, James
Retraying bubble cap columns..July 25 *134
Trimble, Floyd
What engineers should know about patents and claims.....Oct. 3 113
Troyan, J. E.
Hints for plant startup
Part I Troubleshooting new processes .....Nov. 14 *223
How to prepare for plant startups in the chemical industries.....Sept. 5 *107
Vanderbeck, R. W.
Special carbon steels.....May 30 103
Vlibrandt, F. C. & C. E. Dryden
Process control instrumentation.Jan. 11 124
Wachter, Aaron
Proper design voids equipment corrosion .....Feb. 22 *162
Walas, S. M. & C. D. Spangler
Process equipment nomograph..Mar. 21 173
Webber, W. O.
Under fouling conditions—finned tubes can save money.....Mar. 21 *149
Wellman, P. & S. Katell
Nomograph gives pump horsepower Dec. 12 176
Wheaton, R. M. & A. H. Seamster
Ion exchange becomes powerful processing tool.....Aug. 22 *115
Wherry, T. C.
Chemical process systems engineering Dec. 12 *153
White, G. E. & S. C. Hyman
Constant rate filtration scaleup.June 13 *219
Whitley, D. L. & E. E. Ludwig
Find effective length of U-tubes.June 27 *111
Whitney, F. L., Jr.
Corrosion-control design—heat exchangers .....Oct. 17 *214
Wicks, Moye, III
Better way to measure two-phase flow July 11 *152
Williams, Theodore J.
Systems engineering
Pt 1—Feb. 8 *121, Pt 2—Mar. 7 *131, Pt 3—Apr. 4 *139, Pt 4—May 2 *121, Pt 5—May 30 *97, Pt 6—June 27 *113, Pt 7—July 25 *119, Pt 8—Aug. 22 *127, Pt 9—Oct. 17 *181, Pt 10—Nov. 14 *227, Pt 11....Dec. 26 101
Windisch, Richard P.
Economy warms to chemurgy..June 13 94
Wing, R. H.
How to set up operator shift schedules Dec. 12 *182
Witherspoon, R. T.
Ductwork .....Dec. 26 110
Wright, J. H. & D. R. Smith
The prospects for nuclear process heat Nov. 28 *123
Wroth, William F.
Factors in cost estimating.....Oct. 17 204
Storage and process tanks.....Oct. 31 124
Zapata, Carlos A.
How to evaluate interactions...Apr. 4 160
Timed bench-sized screw feeder..Feb. 8 *144
Zenner, George H.
Low-temperature metals: a roundup Oct. 31 *117
Ziemke, Paul C.
Cut maintenance costs by cylinder care Jan. 25 *124
Ziv, M. H. & Adalbert Farkas
Heated arm simplifies solids distillation problem .....Mar. 7 *158